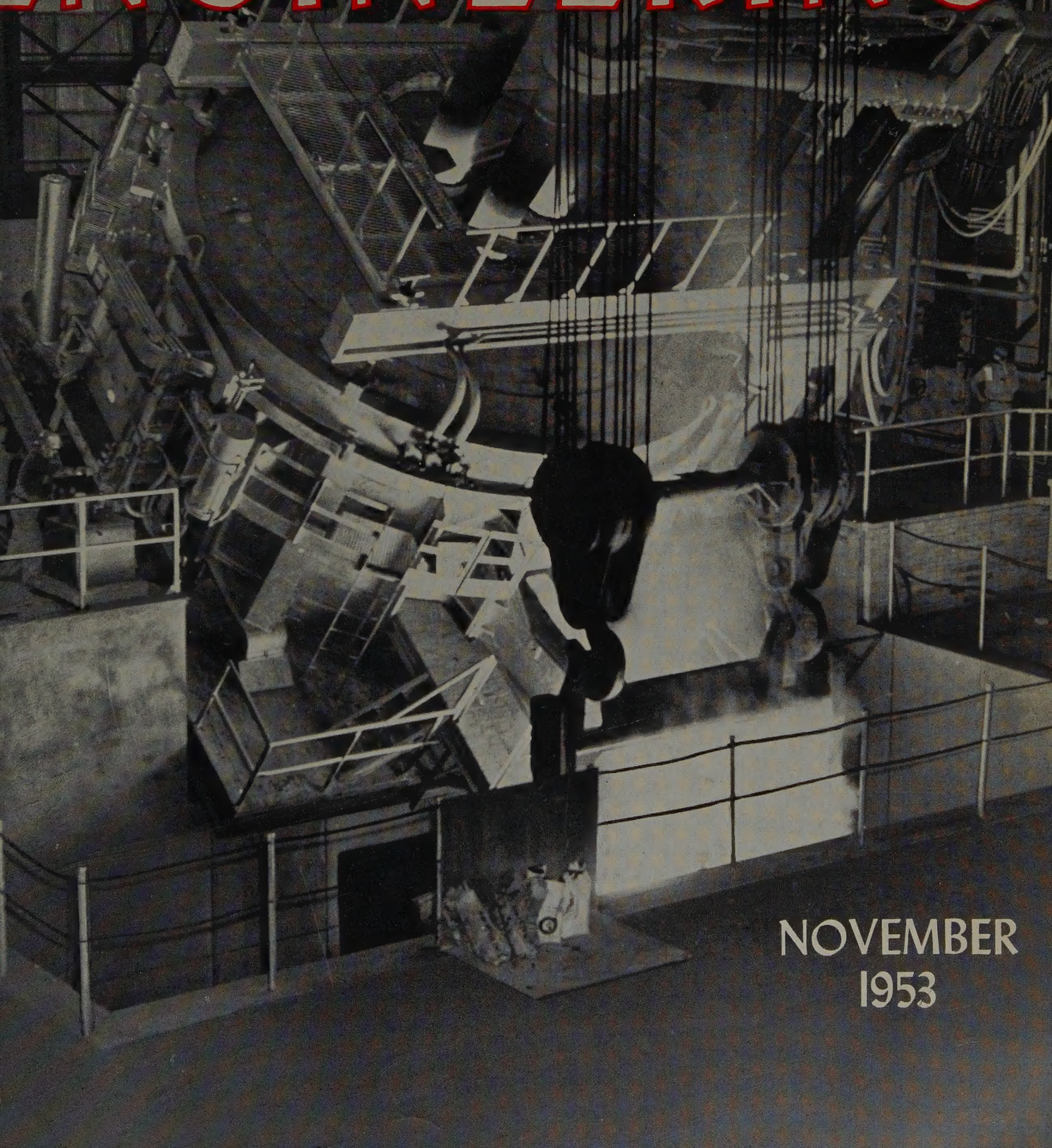
ELECTRICAL ENGINEERING



NOVEMBER
1953

FALL GENERAL MEETING, KANSAS CITY, MO., NOVEMBER 2–6, 1953

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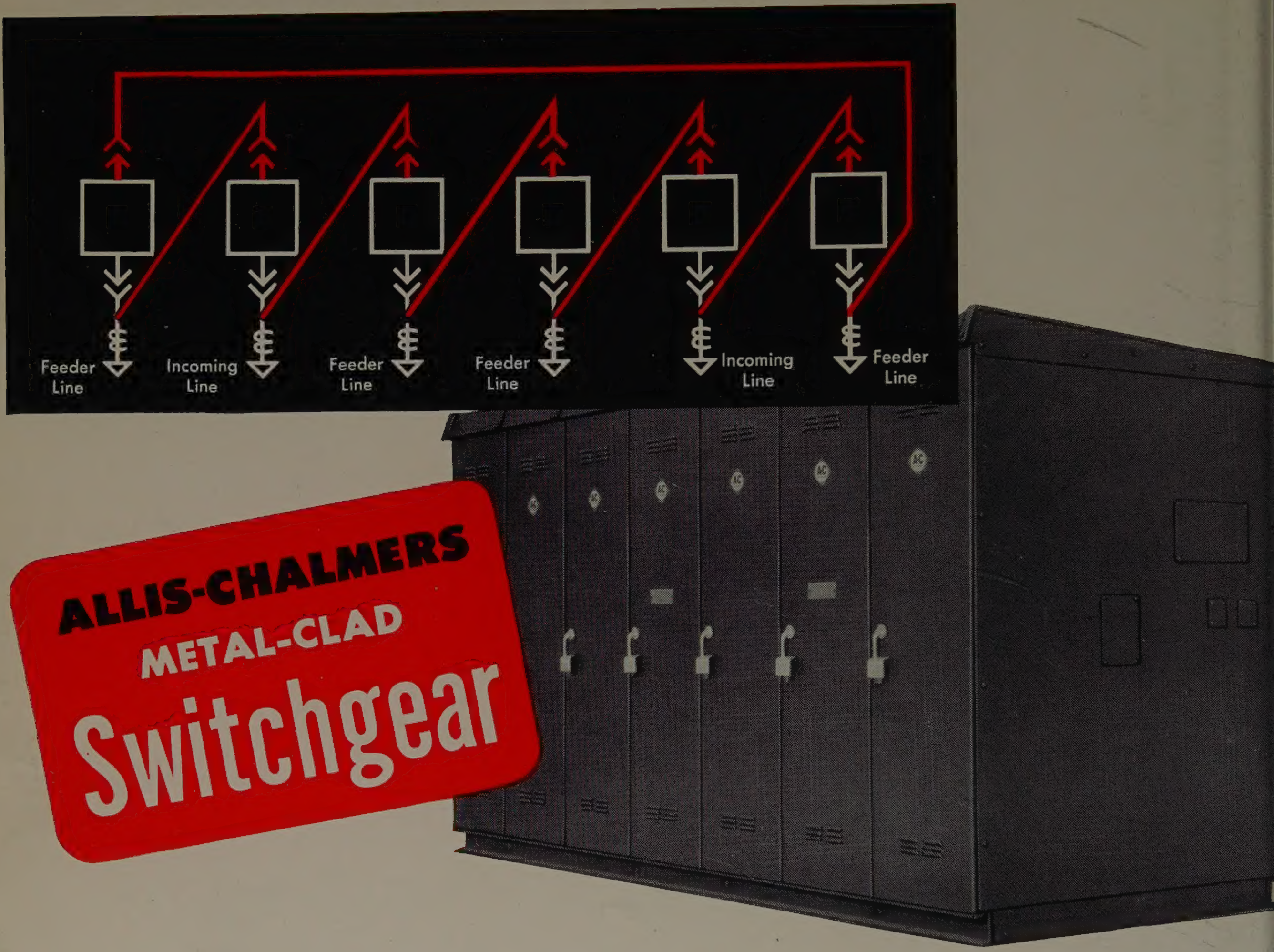

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The Cover: "Tapping a heat" (pouring of molten metal into ladles) from a 100-ton 25,000-kva electric arc furnace at the Sheffield Steel Corporation to be visited during the Fall Meeting. The ladles are below floor level. Advantages of electric furnace steelmaking were considered in September, page 850.

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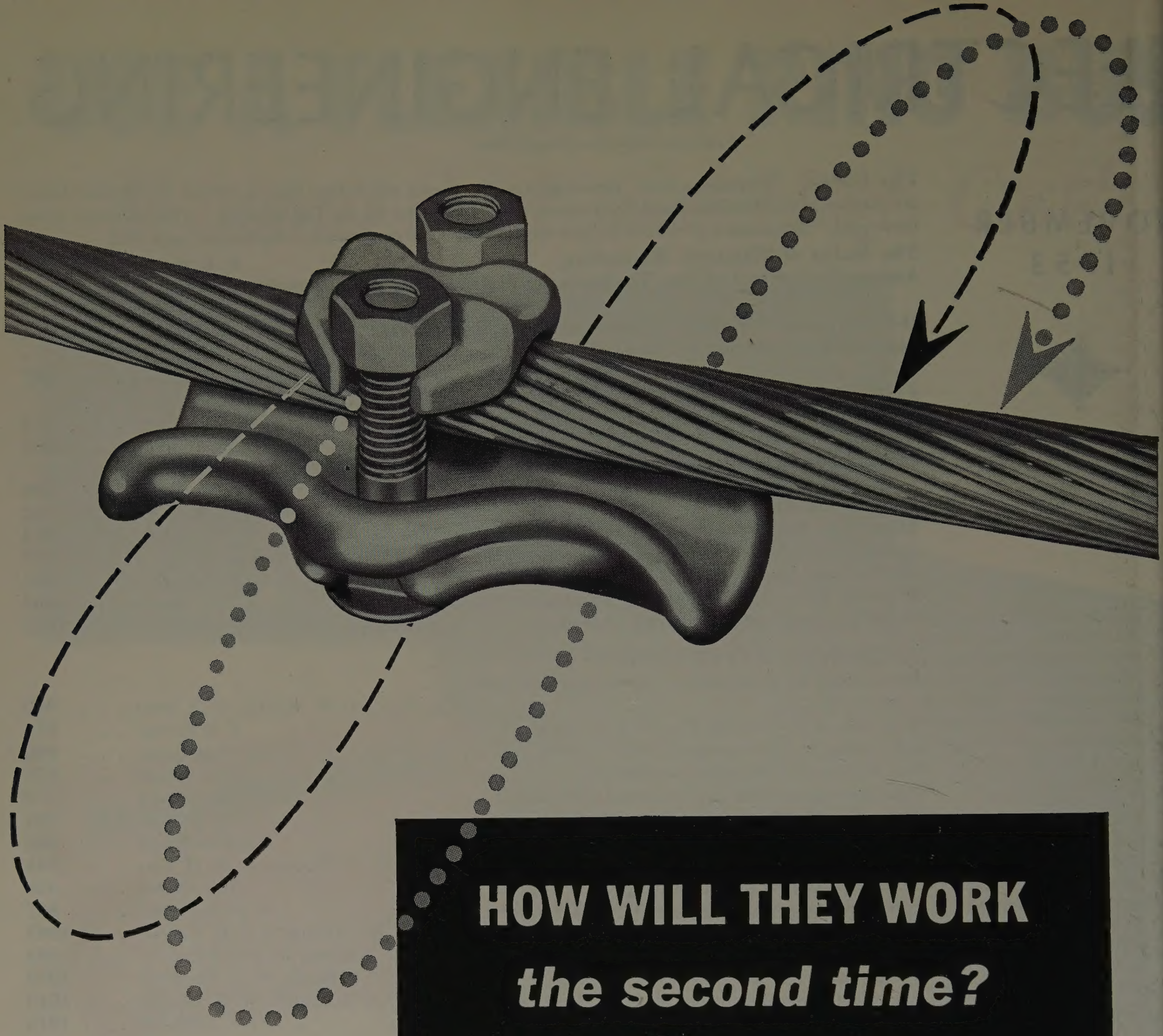

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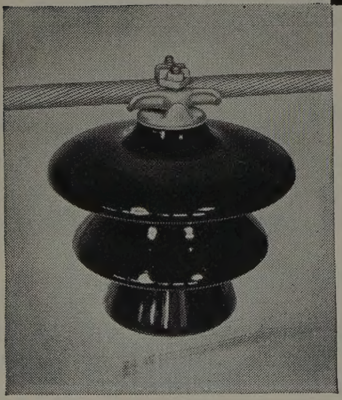

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HIGHLIGHTS . . . .

The Status of Magnetic Recording. Some of the performance characteristics of magnetic recording have decided effects on the design of the apparatus for various types of applications. These characteristics of today's equipment are considered (*pages 951–4*).

Automatically Controlled Gas Turbines for Natural Gas Pipe-Line Pumping. Completely unattended, remotely controlled power transmission stations were foremost in the minds of the designers of the gas turbines and the automatic control. These units, with the addition of telemetering equipment, may be started, stopped, and their speed controlled from any place in the world, while they in turn pump gas and signal all significant conditions to that remote point (*pages 955–9*).

D-C Amplifier Using Junction-Type Transistors. The operation of a d-c transistor amplifier is so greatly affected by drift in the output current that sufficient temperature variation can cause the amplifier to be completely inoperative. By using nonlinear resistors (diodes) as a circuit element, the drift can be compensated considerably (*pages 961–4*).

Lightning Protection in Extra-High-Voltage Stations. Although the impulse strength of the equipment and the protective characteristics of the lightning arresters at their terminals may be known, the effect of distances between arresters and equipment and the electrical characteristics of various station equipment alter the waveshape of an incoming impulse by the time it reaches various points in the station. Test data based on the results obtained with various types of impulse voltage waves entering a simulated station are presented and discussed (*pages 967–72*).

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Telephone System Applications of Recorded Machine Announcements. Of the three common types of voice-reproduction equipment, the telephone announcement work has utilized the optical and magnetic methods more than the mechanical method. The four general groups into which these announcements may be divided are discussed in some detail (*pages 975–80*).

Raydist Systems for Radiolocation and Tracking. Since the end of World War II, the wraps have been removed from several methods of getting "fixes" on the earth's surface and tracking by radio. The Raydist systems use the heterodyne method of making phase-comparison measurements, which are described together with some applications (*pages 983–7*).

A Critical Soil Moisture Condition Affecting Buried Transmission Lines. Although based upon experimentation with an idealized soil, the results may be applicable to real soils such as silts and sandy soils. It was found that the critical condition existed when the moisture content is approximately 4 per cent by weight, so that two different phenomena are responsible for heat dissipation in buried heat sources (*pages 989–92*).

A Complex Algebra for Relay Circuits. The basic principles of symbolic logic are applied to Montgomerie's algebra. A complex notation is introduced for circuits having contacts in parallel with relay coils (*pages 992–3*).

Substation 1-Line Diagrams. The 1-line diagram indicates by means of single lines and simplified symbols the route and component devices or parts of an electric circuit or system of circuits. In this article, a Working Group on 1-Line Diagrams investigates the basic primary circuit electrical configurations for transmission and distribution substations (*pages 998–1002*).

Oil Burner Master Control. Demand for a simplified master control to direct and supervise the operation of domestic oil burners is recognized in the development of a new control consisting of a combination transformer-relay, flame detector, and thermal timer. A new circuit, materials, and process are discussed in detail (*pages 1005–08*).

Miniature Fuses for Appliance Circuits' Protection. These fuses have many applications, being used in appliances for overload protection and short-circuit isolation. Their development is discussed and the various types compared, and the specifications for them are compared with those for service-type circuit breakers. Recommendations that should prove helpful to both the fuse and appliances industries are presented (*pages 994–5*).

Bimonthly Publications

The bimonthly publications, ***Communication and Electronics***, ***Applications and Industry***, and ***Power Apparatus and Systems***, contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Oil Refinery Modern Electric Distribution System. As electricity plays a leading role in the operation of any modern oil refinery, a dependable and efficient power supply is necessary and must have an equally satisfactory distribution system. The principal features of such a distribution system are discussed in some detail (*pages 1008–11*).

Field Testing 400-Kv Circuit Breakers. In the Swedish 400-kv network, extensive field tests have been made with three types of circuit breakers. The switching overvoltages are measured by interrupting lines and transformers at voltages up to 540 kv. The highest overvoltage factors measured during the tests was 2.4 (*pages 1015–20*).

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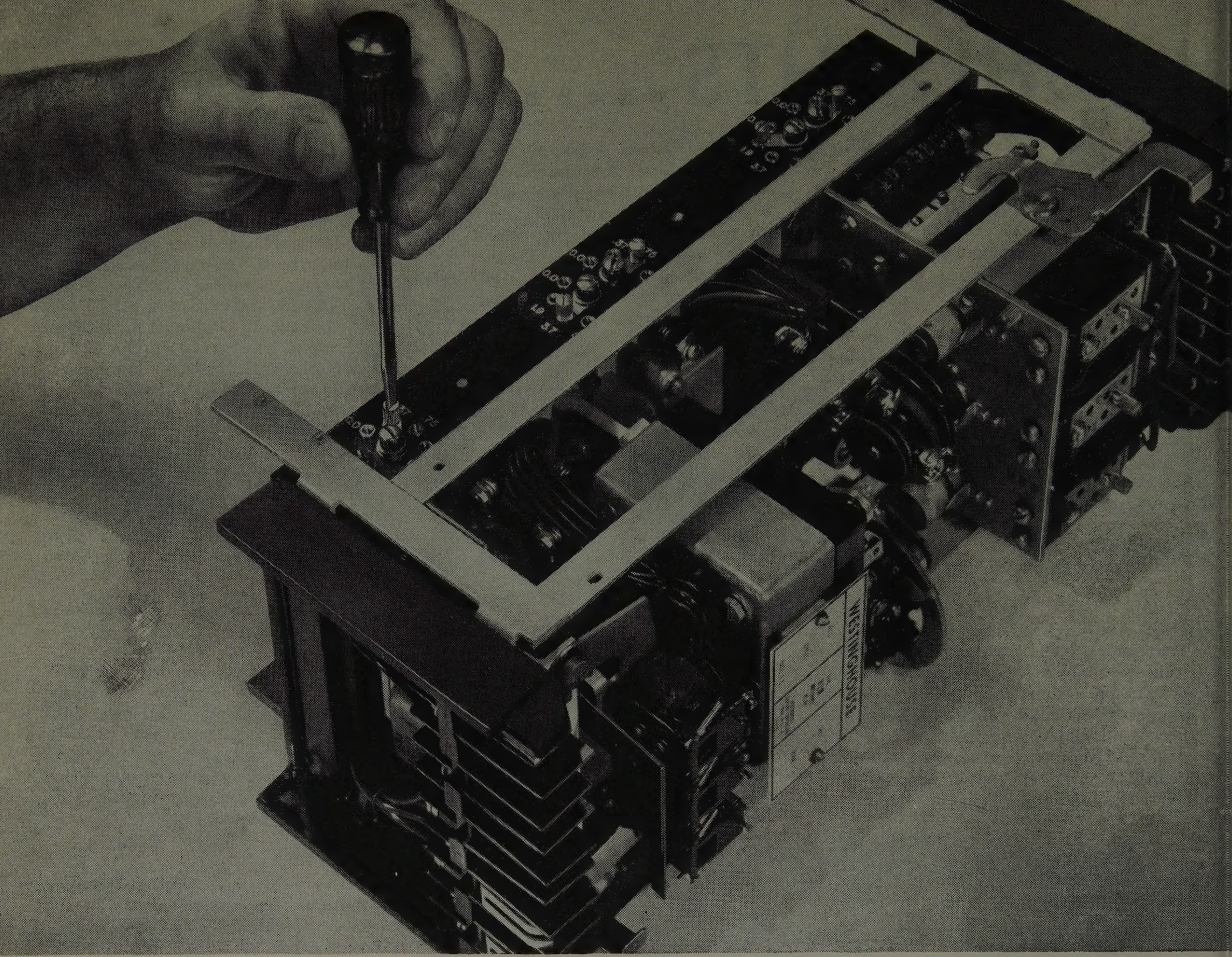

New built-in impedance modifier in Westinghouse relay saves switchboard space

The Westinghouse HZM Distance Relay now has a *built-in* network for offsetting the impedance circle. Previously, this unit was housed in a separate auxiliary box which had to be mounted on the rear of the switchboard. Mounting the impedance modifiers within the relay case provides a compact, self-contained unit which saves switchboard space. An additional advantage is the saving of wiring formerly required between relays and the auxiliary. It is also easier to test the improved relay both in the laboratory and in the field.

Adjustable Impedance—The network for offsetting the impedance circle used in the HZM Relay is particularly valuable on long lines or heavily loaded lines. The HZM can be set to include minimum fault ohms but to exclude maximum load ohms. This discrimination is possible because of the difference in phase angle between the two, even though the magnitude of the fault ohms is equal to, or less than, the magnitude of the load ohms.

Westinghouse also makes the HZ-4 Relay in which the first two impedance elements are not offset, while the third element is offset, as in the HZM. This unit is ideal for use when the first two elements serve shorter lines.

Out of the Westinghouse Relay Laboratory in Newark, N.J., has come, through the years, a constant parade of relay "firsts". For the finest relay engineering, the very latest relay developments, look to Westinghouse.

For more information on the HZM or HZ-4 Relays, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40456

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The Status of Magnetic Recording

R. E. ZENNER
MEMBER AIEE

The recording of sound on magnetic tape has reached a high degree of fidelity; its use has expanded into the computer field and experiments are being conducted on the recording of television signals. Its performance is here considered in relation to various applications.

CERTAIN performance characteristics of magnetic recorders have decided effects on their design for various applications. There are four broad fields of application in which magnetic recorders are recognized: 1. Sound Recording, 2. Digital Data Recording, 3. Physical Analogue Data Recording, and 4. Video Recording.

This list covers most of the applications of magnetic recording to date. The desirability of certain design techniques for particular applications becomes apparent as the ways are considered in which magnetic recording falls short of an absolutely ideal recording system. The inherent advantages and great design flexibility of magnetic recording systems make them the favored choice for many new applications as the needs appear. By means of magnetic recording, services are now being rendered which once were considered beyond hope of attainment.

To extend still further the usefulness of this art, its faults and shortcomings should be analyzed critically.

SOUND RECORDERS

THE BEST of the present magnetic-tape sound recorders are so good that only very highly skilled listeners can tell whether a program heard from a loudspeaker is an instantaneous presentation from a live studio program or a tape-recorded program. Skilled listeners may detect a difference due to the phenomenon known as under-signal noise. This near-perfection of magnetic sound recorders might lead one to think that the same instruments ought to be equally good for all other recording applications. Unfortunately this is not the case, and with a little investigation it was found that the design compromises in recorders for sound have been made to take advantage of perceptive deficiencies in the ultimate sound recorder test instrument, the human ear. Some perceptive limits of the ear are

1. No d-c level or extreme low-frequency perception.
2. No very-high-frequency perception; 20 kc or so is the limit for young adults and this decreases with age.
3. Wide tolerance for phase shifts. Almost no wave-shape perception, as distinguished from harmonic amplitude content.
4. Does not perceive small "holes of silence" in a record.

The ear is very critical of:

1. Pitch variations.
2. Intermodulation distortion.
3. Background noise.

Designers of sound recorders properly have made their selections of the various design parameters to achieve best apparent performance when judged by the human ear. Tape drive systems have been engineered carefully for very little flutter or wow; high-frequency bias techniques and magnetic powders for tapes have been developed for very low harmonic and intermodulation distortion, and background noise has been made negligible by adequate dispersion of magnetic powder in the tape, by limpness of the tape, and by very low coercive force in the iron from which heads are constructed. These and some other developments have made possible the present high performance of the best magnetic-tape sound recorders.

Now consider some of the basic limitations of longitudinal magnetic recording with high-frequency bias. A good place to start may be wavelength limitations.

LONG WAVELENGTHS

THERE IS NO difficulty in recording extremely long wavelengths, but there is difficulty in playing them back. To a first approximation, playback voltage is inversely proportional to wavelength at constant tape speed, since playback voltage is proportional to the time derivative of flux change. On a frequency basis this means a response curve rising at 6 decibels per octave. When wavelengths are very long compared to the dimensions of the playback head, this 6-decibel-per-octave rule no longer applies and an 18-decibel-per-octave rule takes over. See Figure 1. In this region, much of the external flux from the tape completes its path through air without threading the playback coil. Both the peak flux and the rate of change of flux are reduced. At infinite wavelength no flux from the tape threads the coil, and there is no response from the head.

Recently a playback head embodying magnetic amplifier principles has been described. This head is like some traditional magnetic amplifiers except that control flux is derived from the tape rather than from ampere turns in a control coil. The output is in the form of second harmonic of the a-c excitation to the head. With this head, the 6-decibel-per-octave rule no longer applies, but the additional 12 decibels per octave at extremely long wavelengths does apply. In other words, this magnetic modulator head has response down to zero frequency, but not to infinite wavelengths. The head can read the residual flux in a stationary tape provided that the magnetization changes sufficiently along the tape length, so that substantially all the external

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Full text of conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953.

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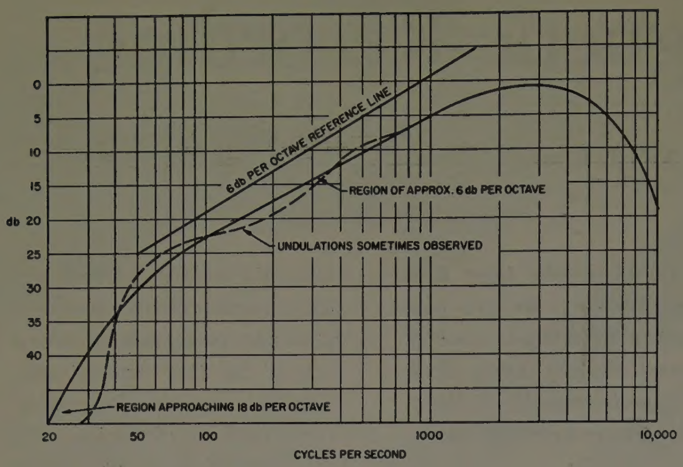

Figure 1. Constant current response for 7.5-inch-per-second tape speed

flux from the tape enters the head. If direct current is recorded (infinite wavelength) the head cannot read it, but if alternating current is recorded, the tape may be slowed down or stopped in playback to read steady-state values from the original a-c recording.

At the present time no means is known to play back extremely long wavelengths longitudinally recorded, and this is a handicap to some physical analogue recording applications where steady-state values are desired. Transverse or other recording patterns may be used in connection with magnetic modulator heads to fulfill such a requirement.

In longitudinal recording, wavelengths up to approximately 3/8 inch have been used to produce signals which exceed noise levels in amplifiers and stray field effects by a useful amount. Special head constructions with a long contact between head and tape may be used to play back somewhat longer wavelengths. Playback of long wavelengths is further complicated by the spurious playback responses which occur at the initial and final points of contact with the head. These produce the familiar "bumps" in the low-frequency end of response curves.

SHORT WAVELENGTHS

Extremely short wavelengths are also easier to record than they are to play back, but unlike the very long wavelengths, attenuation is experienced in the recording itself. A number of effects enter here:

1. Fringing and partial erasure by bias flux.
2. Inaccuracies of the final gap edge.
3. Loss of resolution due to thickness of the recording medium layer.
4. Interference effects which may be described as successive individual recordings made at the initial and final recording gap edges.
5. Self-demagnetization effects at short wavelengths.
6. Imperfect contact conditions between tape and head.

Despite this impressively long list of deleterious effects in the recording of short wavelengths, one usually finds the most serious limitations in the playback process such as:

1. Gap length.
2. Azimuth error (angular position of the playback gap relative to the recording gap).
3. Imperfect head-tape contact conditions.

With limp tapes and ordinary care in head construction, wavelengths of 0.001 inch may be utilized readily. With extra care, wavelengths of 0.0005 inch may be reproduced with signal levels which exceed noise by a satisfactory amount.

The ultimate limits of resolution in the coatings of modern tapes have not been approached as yet. The practical limitations lie in the tape base materials, head construction, and the intimacy of tape to head contact. Sound recorders have been using lower and lower tape speeds as time goes on. See Figure 2. It has been remarked about this curve that it seems to indicate that magnetic recording will be at a standstill by 1956.

FREQUENCY EFFECTS

The difficulties encountered in very-low-frequency or d-c amplifiers are well known and need not be treated here. Suffice it to say that the magnetic recording and playback processes present no low-frequency problems as distinct from the long-wavelength problem discussed previously, and the amplifier problem.

At high frequencies, however, some problems do appear which are distinct from short-wavelength problems and amplifier design problems. Eddy-current effects in heads constructed of solid metals prevent very rapid flux changes. This is most bothersome in the erasing and recording processes because high flux densities accentuate eddy-current effects. In playback, the flux density in the heads is so low that much less serious eddy-current phenomena are noted. High-resistivity core materials (ferrites) are finding a place in very-high-frequency recording work. Magnetic resonance effects may set an upper frequency limit for these.

Head geometries which provide short flux paths are advantageous if the signals to be recorded have high-energy content at high frequencies. Eddy-current shields are also useful in reducing leakage flux. Stray capacitance may be a problem also as in any high-frequency circuit.

INPUT-OUTPUT CURVES

A family of input-output curves is illustrated in Figure 3. These are plots on log-log paper of output level versus input level for various frequencies. A perfect system would result in all points falling on a 45-degree line. It will be noted that the curves for the various frequencies have slopes other than 45 degrees even in their most nearly linear regions. The same kind of experimental data may be

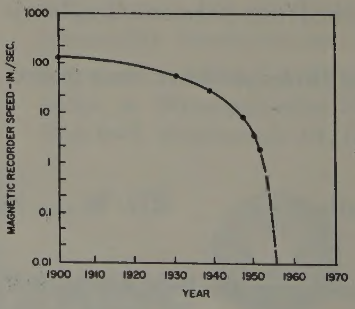

Figure 2. Trend of speeds of typical magnetic recorders

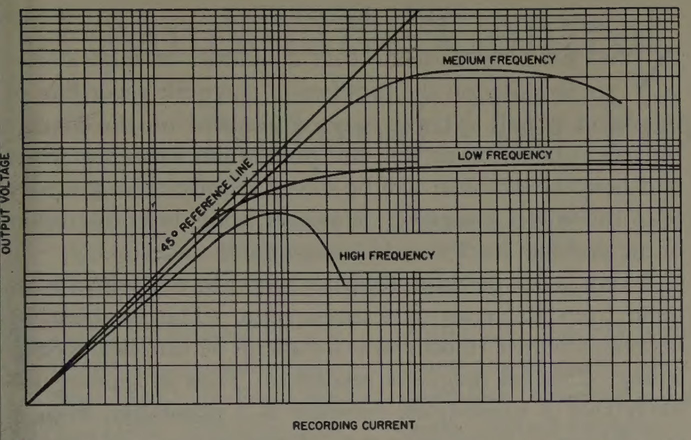

Figure 3. Input recording current-output voltage effects for different frequency ranges

plotted as frequency-response curves for various input levels. A family of such curves is shown in Figure 4.

A volume compression phenomenon exists in magnetic recording, and its effects are most pronounced at short wavelengths (high frequencies). This is a most difficult form of distortion to compensate; in fact, compensation for it is simply not attempted.

PHASE SHIFTS

THE MANY mechanisms which act to attenuate one frequency relative to another are normally accompanied by phase shifts. In networks composed of linear passive elements there is a certain minimum phase shift for any attenuation curve. In magnetic recording, however, the self-demagnetization effect is capable of producing more attenuation of one frequency than another without relative phase shift. The level of residual magnetization of short wavelengths simply decreases without necessarily shifting the positions of peak and zeros of magnetization in the tape.

Other attenuation phenomena are accompanied by the familar phase-shift effects encountered in ordinary networks. However, the existence of the self-demagnetization effects restricts successful waveshape equalization to limited categories of waveforms having a limited frequency spectrum.

Figure 5 shows the playback waveform resulting from the recording of a square wave, using equalization networks which seemed to give about the best waveshape representation.

NOISE

WHEN MODERN TAPES are properly erased, they exhibit a noise level so low that the measurement of this noise level becomes very difficult, due to masking by amplifier noise. This is noted in good tape sound recordings as complete absence of any perceptible background noise.

In the presence of signal, however, the noise level rises. This is undesirable in any application of recording, but is somewhat less objectionable in sound recording than in physical analogue recording. In the latter application it appears as an amplitude uncertainty. If one records a steady sine wave, the playback voltage fluctuates in amplitude. In many cases this fluctuation amounts to about 5-per-cent amplitude modulation of the sine wave at quite low and rather random modulating frequencies. Such a modulated wave includes side-band frequencies. It has been shown that the under-signal noise energy is greatest at frequencies near the intended recorded frequency. This is, in fact, just another way of showing that the modulation of the sine wave occurs at low frequencies, so that the side-band frequencies are not far removed from the intended frequency. The main cause of this amplitude uncertainty or under-signal noise is fluctuation in the contact condition between tape and head during the recording or playback process or both.

Severe modulation or reduction of signal amplitude occurs if a nodule of coating material or foreign material provides a hill on the tape surface. As such a bump rides across the head (either recording or playback) it lifts the main body of the tape away from the head during its entire passage across the head, and causes very large attenuation of signal for that period of time. See Figure 6. Such "holes of silence" are bridged over by the hearing mechanism when listening to sound recordings, but digital computers have not yet been trained to accomplish this feat. Great care is required in the initial inspection and subsequent handling of computer tapes to avoid this problem.

In drum recorders for digital computers, wear problems usually dictate that the heads be spaced away from the record surface. This spacing causes a very considerable loss of signal and of resolution, but has the advantage that percentage spacing error may be reduced when one aims at 0.001-inch spacing as compared to aiming at zero spacing. Thus this drop-out form of noise is rarely experienced in such drum storage systems.

In any magnetic recording system noise problems are reduced in severity by the use of more recording area. There is economic pressure to try to use narrow tracks and high resolution in all the forms of magnetic recording, and some quite phenomenal successes have been achieved along this line. In pressing for minimum recording medium area, additional problems are placed before mechanical designers and electronic circuit designers. The mechanical designer must maintain closer tolerances in order that the heads adequately contact the right place on the record medium at the right time, and the electronic designer must get along with weaker signals, and must depress his circuit noise to use them.

CARRIER TECHNIQUES

SOUND RECORDING and digital data recording are adequately handled without resorting to recorded carrier

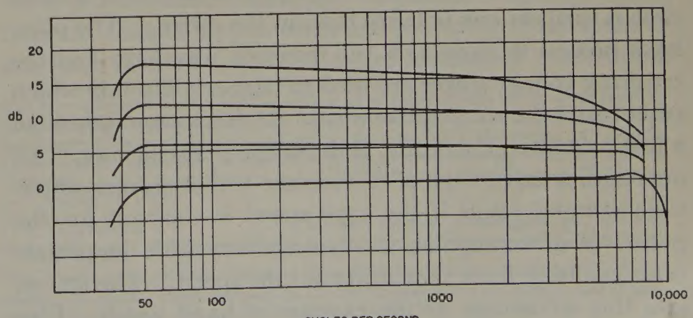

Figure 4. The effect of level on frequency response of an equalized system

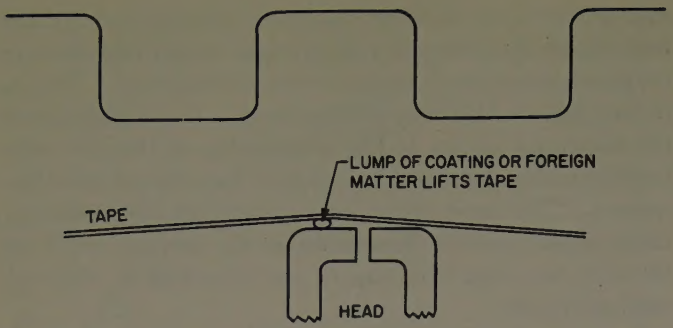

Figure 5 (top). The reproduction of a square wave in an equalized magnetic recorder. Figure 6 (bottom). Modulation or reduction of signal amplitude occurs when a speck of foreign material lifts the tape off the head

waves. However, in present practice, carrier waves have proved very beneficial for physical analogue data recording, and in the future they may provide a practical solution to the video recording problem.

The various frequency and wavelength response, phase response, volume compression, and amplitude uncertainty phenomena described previously make direct recording of physical analogue data unsatisfactory for many applications. Amplitude modulation of a carrier wave by the intelligence frequencies sometimes is used, but has an inherently low signal-to-noise ratio due to the amplitude uncertainty phenomenon.

A much better result is accomplished by recording a frequency-modulated carrier. In this case the main burden of accuracy is transferred over to the tape-driving mechanism, and it turns out that tape drives can be held to such close tolerances that excellent physical analogue data recording can be accomplished. The price one pays is that much larger volumes of tape must be used, and the frequencies actually recorded and played back are very much higher than the intelligence frequencies, thus setting an upper limit, but no lower limit on the intelligence frequencies. Frequency-modulated recorders have been further refined by utilizing a pure carrier control track to provide a correction signal to act upon either the playback tape drive system or the center frequency of the playback discriminators to correct speed errors and thus increase signal-to-noise ratio.

Another carrier technique which is finding favor is pulse-width-ratio modulation. In this scheme, the recorded waveform is rectangular, and is symmetrical when the intelligence amplitude is zero. For other intelligence amplitudes the recorded wave is made asymmetrical, that is more time is spent in one polarity than in the other. The playback process differentiates the recorded waveform and the resulting voltage spikes are used to trigger a flip-flop which regenerates the rectangular wave. If this is passed through a low-pass filter, the output is the original intelligence. An outstanding advantage of this scheme is that correct amplitude samples result if the tape speed is constant for the period of a rectangular wave, with very little amplitude error resulting from slow drifts of tape speed. The system gets this advantage at the expense of band width. Like frequency modulation it encounters an upper intelligence frequency limit but no lower limit.

VIDEO RECORDING

News releases indicate that a number of laboratories are working on the problem of magnetic recording of television signals. There is no equipment on the market for this application as yet, and predictions as to just when and how the problem will be solved require more temerity than this writer possesses. However, some brief discussion of the problem itself may be a reasonable undertaking.

A very good television recorder might be one with a pass-band from 20 cycles to 4 megacycles. This is about 18 octaves, whereas 10 octaves is a difficult accomplishment in a single-channel magnetic recorder. Thus it appears unlikely that a single-track recorder is a possibility, even if one chooses to allow some degradation as compared to the ideal. One then may decide that several tracks will be used in some manner to take care of the bandwidth problem, and start looking at the upper frequency limit. Now 4 megacycles at 0.0005-inch wavelength dictates a speed of 2,000 inches per second or about 114 miles per hour. Tapes actually have been run at this speed for very brief periods, but with very destructive results. In laboratory tests at 1,000 inches per second, a frequency of 1.5 megacycles has been recorded and played back. It is believed that about 500 inches per second is the maximum speed that existing tapes might be run with reasonably satisfactory life. Now if we could rely on 0.0005-inch wavelength at this tape speed we could have an upper frequency limit of 1 megacycle, but the contact problem increases with tape speed to such an extent that this performance might be only a laboratory curiosity rather than a solid commercial achievement.

Carrier techniques have proved useful in solving the very-low-frequency performance problems of physical analogue data recording, and various organizations are considering them to solve the high-frequency and bandwidth problems of video recording. If a number of tracks and an electronic commutator of some sort are used, we might sample the video signal and record the sample amplitude in smeared-out fashion on one of the low-resolution tracks. The next sample would be routed to the next track, and so forth, until upon coming around to the first track again, we may have passes outside the limits of the smear previously recorded on that track. For playback, we would have to read the signals from each track through a properly timed electronic commutator so as to put together a single high-resolution signal from the multiple, staggered low-resolution tracks.

It remains to be seen whether this or some other technique will be successful in actually serving the need for a television recorder.

CONCLUSION

Magnetic recording has an impressive record of past accomplishments and offers high hopes for further future accomplishments. It has faults but these are often less troublesome than the faults of some competitive forms of recording. In many fields, engineers are successfully trading one performance parameter for another (as in the use of carrier techniques) to satisfy the needs of particular applications, by means of magnetic recording.

Automatic Control of Gas Turbines for Natural-Gas Pipe-Line Pumping

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Automatic control equipments for the 5,000-horsepower gas turbine designed for natural-gas pipe-line pumping are described in terms of the main control equipment, mechanical, electrical, and hydraulic turbine control components, and the Cabinetrol panels for station and turbine auxiliaries.

IN AN EXPANSION era in the natural-gas pumping field rivaling the building of the railroads, considerable interest has developed in the application of gas turbines, driving centrifugal compressors for the pumping of natural gas. Since overall system reliability and continuity of service are the watchwords in natural-gas pumping, the gas turbine fulfills all requirements. Its features—relatively simple construction, automatic operation, self-sustaining, self-protecting, low installation and maintenance costs—indicate that the gas turbine is an excellent prime mover for pumping natural gas through long-distance pipe lines.

A detailed description of the application of the gas turbine for gas pipe-line pumping was given by J. F. Eichelmann and J. S. Quill.[*] The design details of the 5,000-horsepower gas turbine have been presented by B. O. Buckland and D. C. Berkey.[†]

Pumping stations often are located in isolated areas. Therefore, control equipment must be arranged so that the gas turbine can be controlled with a minimum of skilled operating personnel. Also, provision must be made for starting, loading, and stopping the pumping equipment in the shortest possible time with the least number of manual operations. Automatic control, given a single start or stop signal by a station operator or remote dispatcher, fulfills these requirements.

Figure 1 shows in schematic form the components of a natural-gas pipe-line pumping 5,000-horsepower gas-turbine equipment which must be controlled to place a pumping unit in or out of operation. Figure 1 also includes the schematic gas-line piping for a 4-unit natural-gas pipe-line pumping station with a total rated capacity of 20,000 horsepower. This is the maximum contemplated for any one station at the present time.

Essentially, the control equipment for a pumping unit consists of three components: 1. The main control equipment; 2. the mechanical, electrical, and hydraulic control elements of the turbine; and 3. the Cabinetrol[‡] panels for the station and turbine auxiliaries.

MAIN CONTROL EQUIPMENT

THE MAIN PORTION OF the automatic control circuits and the associated control devices for a pipe-line pumping gas-turbine equipment is centralized in a duplex control board, which is shown in Figure 2.

Control Devices. Speed responsive relays and motor-driven timing relays are the heart of the automatic control equipment for starting and stopping a gas turbine pumping unit. These relays function to control the various steps in the operating sequence. The speed relays operate in response to the rectified output of tachometer generators coupled to the shafts of the high- and low-pressure turbines. The motor-driven timing relays, which operate either directly or indirectly from speed relay signals, control such functions as turbine and duct purging, gas compressor purging and pressurizing, valve operation, and turbine cooling. Contact multiplying auxiliary relays provide the necessary interlocking for correct sequence operation. A pressure regulator which responds to a station discharge pressure signal controls the gas turbine speed and loading to maintain the desired station discharge pressure.

Operation Sequence. The control circuits are arranged so that the starting signal will initiate the starting sequence of the gas-turbine pumping equipment only when all prestarting conditions have been satisfied. When the circuit breakers for the auxiliary and emergency lube-oil and emergency nozzle-cooling water pumps are closed, protective-device trip contacts are reset and control air pressure and battery charge are normal, three green lamps are lighted indicating that starting conditions are correct. The failure of one of these lamps to light will indicate to the operator which one of the three control components is the source of prestarting trouble.

The starting sequence is initiated when the operator turns the master control switch to the "start" position. The automatic control circuits then will complete the operations as shown in Figure 3. When the first unit in a station is started, the operator closes the station by-pass valve at a convenient time and the pressure regulator maintains the desired station discharge pressure. The operator can have manual control of either station- or unit-loading

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Full text of paper **53-323**, "Automatic Control of Gas Turbines for Natural-Gas Pipe-Line Pumping," recommended by the AIEE Committee on Chemical, Electrochemical, and Electrothermal Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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[*] Gas Turbine Centrifugal Compressor Stations for Gas Pipeline Pumping, **J. F. Eichelmann, J. S. Quill.** Paper presented at the Spring Meeting of the Natural Gas Department of the American Gas Association, held at Dallas, Tex., May 7–8, 1951.

[†] Design Features of a 5,000-Horsepower Gas Turbine, **B. O. Buckland, D. C. Berkey.** Annual Meeting, American Society of Mechanical Engineers, November 25–30, 1951.

[‡] Registered trade-mark of the General Electric Company.

by means of selector valves which operate in conjunction with the pressure regulating equipment. He also can control manually the pressure control signal to the fuel regulator if the control air supply should fail. Full-load condition can be reached in approximately 20 minutes after the starting indication has been given.

During starting, failure of the clutch to engage the starting and high-pressure turbines, failure of the unit to fire, or failure of the automatic starting sequence to be completed within a definite period of time will cause the pumping equipment to be shut down or give an alarm. A pumping unit also is shut down when the operator turns the master control switch to the "stop" position, operates the emergency stopping devices, or when protective devices operate in response to abnormal temperatures or pressures, overspeed, and loss of flame. The stopping signal automatically initiates the shutdown sequence shown in Figure 3.

When the high-pressure turbine coasts to approximately 2-per-cent speed, a motor-driven timing relay is started to determine the length of time the d-c lubricating and cooling water pumps will run to cool the bearings and the turbine. Restarting of the turbine can be initiated any time below 2-per-cent speed.

At the instant any unit is given the shutdown signal, the station by-pass valve is automatically opened and the other units which are running in the station are brought to a minimum load speed by reduction in fuel supply. This is done to minimize the heating of the gas compressor and associated piping. These units will assume normal speed and load when the operator recloses the station by-pass valve.

Annunciation and Alarms. A 36-drop annunciator together with an alarm bell and lamp provide both audible and visual warnings when an abnormal operating condition exists or when a protective device operates to shut down the turbine.

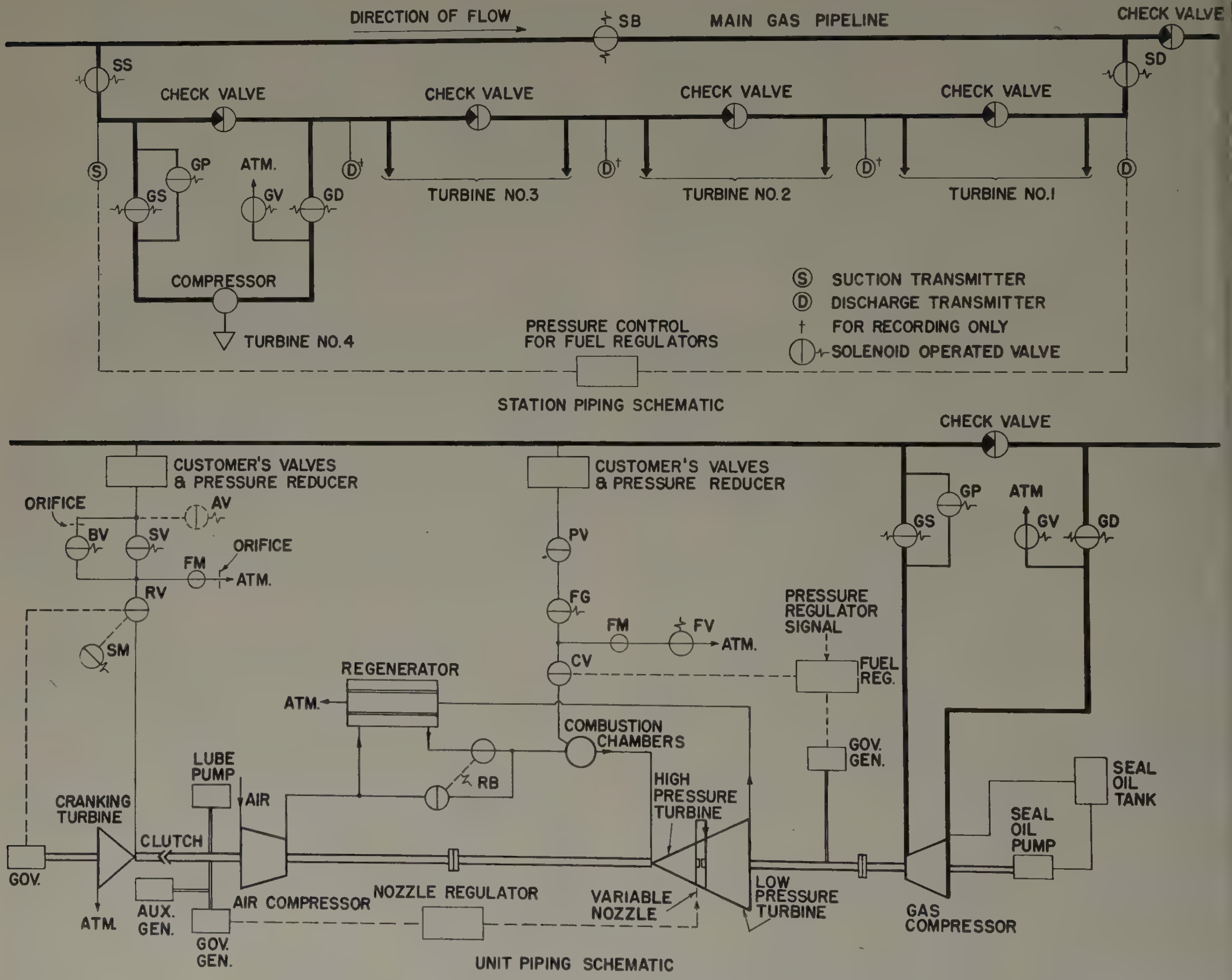
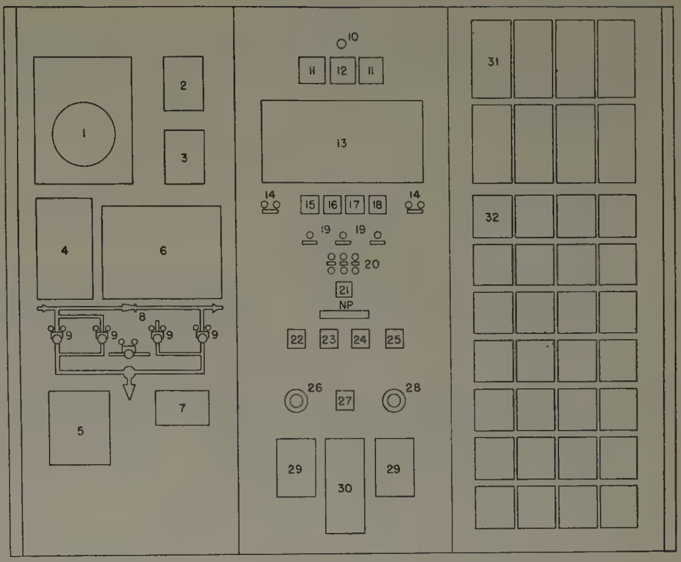


Figure 1. Typical piping schematic for gas turbine pumping station

AV—Alcohol valve; BV—Starting by-pass valve; CV—Gas control valve; FG—Fuel gas stop valve; FM—Flow meter; FV—Fuel gas vent valve; GD—Gas compressor discharge valve; GP—Gas compressor pressurizing valve; GS—Gas compressor suction valve; GV—Gas compressor vent valve; PV—Pressure ratio valve; RB—Regenerator by-pass valve; RV—Starting regulating valve; SB—Station by-pass valve; SD—Station discharge valve; SM—Starting mechanism; SS—Station suction valve; SV—Starting stop valve

Figure 2 (right). Front-view diagram of duplex control board for a natural-gas pipe-line pumping gas-turbine equipment

1—Gas pressure indicator-recorder; 2—Station pressure regulator hand-autoselector valve; 3—Unit pressure regulator hand-autoselector valve; 4—Vibration recorder; 5—Vibration recorder control and power unit; 6—Temperature recorder; 7—Temperature recorder unit; 8—Gas compressor piping mimic; 9—Control switches and position-indicating lamps for gas compressor valves; 10—Alarm lamp; 11—Speed indicators; 12—Variable nozzle position indicator; 13—Annunciator; 14—Regenerator by-pass valve position-indicating lamps; 15—Auxiliary generator field ammeter; 16—Auxiliary generator voltmeter; 17—Auxiliary generator ammeter; 18—Running-time meter; 19—Flame-indicating lamps; 20—Sequence-indicating lamps; 21—Master control switch; 22—Voltage-regulator transfer switch; 23—Ignition test switch; 24—Fuel-setting test switch; 25—Operation selector switch; 26—Exciter field rheostat; 27—Phone jack; 28—Voltage regulator voltage-adjusting rheostat; 29—Speed relays; 30—Auxiliary generator watt-hour meter; 31—Motor-driven timing relays; 32—Auxiliary relays



The annunciator alarms are arranged in three groups:

1. Warning only for an abnormal operating condition.
2. Warning for an abnormal operating condition with subsequent shutdown if the condition persists.
3. Shutdown indication.

This arrangement provides an easy means of advising a remote dispatcher about the nature of the trouble when an alarm signal is received.

Provision for operating a station siren and any additional alarm devices which may be required is included in the alarm circuits.

Remote Control. Local operators will control the first pipe-line pumping gas-turbine equipments being installed. However, it is contemplated that the units eventually will be controlled by a remote dispatcher.

Arrangement of the automatic control circuits permits a remote dispatcher to place a unit into operation or shut it down with one start or stop signal. He also will have control of the operation of the station by-pass, suction, and discharge valves.

Provisions are included for transmitting prestarting condition, complete sequence, alarm and station suction, and discharge pressure indications to a remote station.

Indicators and Recorders. Instruments and meters enable the operator to check turbine and gas compressor speeds, turbine variable-nozzle position, turbine running time, and auxiliary generator output. Recorders provide a continuous record of the pumping equipment temperature and vibration conditions, the station suction and discharge pressures, and the unit discharge pressure.

Other Features. A mimic bus on the duplex control board depicts the unit gas-line piping. If the operator desires to alter the operating sequence of the gas line valves from that determined by the automatic sequence, selector switches placed in the mimic bus permit manual control. Indicating lamps furnish a visual check of the valve positions at all times.

Selector switches enable the operator to check the operating sequence, ignition, and fuel regulator operation.

Sound-power telephone jacks are provided to facilitate communication between the various components of the pumping equipment.

Duplex Control Board Construction. Reference to Figure 2 shows that the duplex control board consists of three units. Basically, the front panels of the three units are arranged from left to right to accommodate the following functions:

1. Recording.
2. Control.
3. Relaying.

The exterior of the rear panels are free from devices thus permitting the control board to be placed against a wall. Walk-in-type construction of the control board with entrance doors at both ends provides ready access to all devices for maintenance and adjustment.

MECHANICAL, ELECTRICAL, AND HYDRAULIC TURBINE CONTROL COMPONENTS

The load of each unit is determined by the load turbine speed control which is overridden by turbine exhaust temperature as follows:

The speed signal from the governor generator, the temperature signal from the gas-filled bulb, and the called-for speed signal from the pressure regulator are fed into the fuel regulator which in turn positions the gas control valve to supply the desired amount of fuel to the combustion chambers. Ahead of the gas control valve is a pressure-ratio valve which holds a fixed ratio between the control-valve inlet pressure and the combustion-chamber pressure, thereby limiting the required range of the gas control valve. An electrically operated stop valve is located between these two valves to shut off fuel when desired. See Figure 1.

Maximum efficiency of the gas turbine over the full-load range is obtained by compressing the minimum amount of air required to operate the unit within the turbine-inlet temperature limit as follows:

The required air flow which results in maximum turbine inlet temperature is produced by controlling the speed of the high-pressure set. Positioning of the variable second-stage nozzle determines the high-pressure set speed. Nozzle position is controlled by a nozzle regulator which responds to high-pressure set speed and turbine exhaust temperature. The regulation of the fuel supply in turn compensates for the energy change on the load turbine.

The retractable spark plugs and follow-up flame detectors respectively ignite the fuel and detect the fire in the combustion chambers. Mechanical overspeed and overtemperature limits trip the units in case of control failure.

CABINETROL PANELS FOR STATION AND TURBINE AUXILIARIES

Cabinetrol is a standard system of centralized low-voltage control. Each turbine will have its own Cabinetrol panel. The station auxiliaries will be in a separate panel. Therefore, in a 4-unit pumping station, there will be four turbine panels and one station panel—all of which can be located to suit the station requirements. Thus, the diverse functions of this application are coordinated into similar panels providing a minimum of installation time and simplification of plant construction and operation.

The complete Cabinetrol equipment for a 2-unit station is shown by the 1-line diagram, Figure 4.

Since many of these pumping stations are located in isolated areas, the electric power supply for each station is designed to be completely self-contained. Each station has three independent sources of electric power:

1. A station storage battery.
2. A gas-engine-driven a-c generator.
3. An a-c generator gear-driven from the high-pressure shaft of each gas turbine.

The 60-cell 400-ampere-hour (8-hour rate) station battery, together with a 25-ampere 125-volt d-c phano-charger (two chargers in parallel are used for a 3- or 4-unit station), furnishes d-c power for the main turbine control and supervisory circuits, emergency lighting, and the essential auxiliaries—such as the auxiliary and emergency lube-oil and the emergency nozzle-cooling water pumps—if the turbine-driven generator fails and the gas-engine-driven generator is shut down.

The gas-engine-driven generator can be used to supply power to the station a-c busses, or, if a turbine-driven generator is out of service, to feed the auxiliaries of that turbine. The latter can be accomplished by closing the bus tie contactor between the station and turbine busses.

The turbine-driven auxiliary generators supply all of the a-c power for their own auxiliaries under normal operating conditions. However, the station auxiliaries can be supplied from the turbine bus if required. Normal starting will be without any external supply of a-c power available. At approximately 45-per-cent turbine speed, the turbine generator is connected to the turbine bus. To prevent overloading of the generator by simultaneous starting of the turbine auxiliaries, a sequence timing relay energizes the auxiliaries at 5-second intervals. The auxiliaries are designed for operation over a range of 220 to 480 volts at

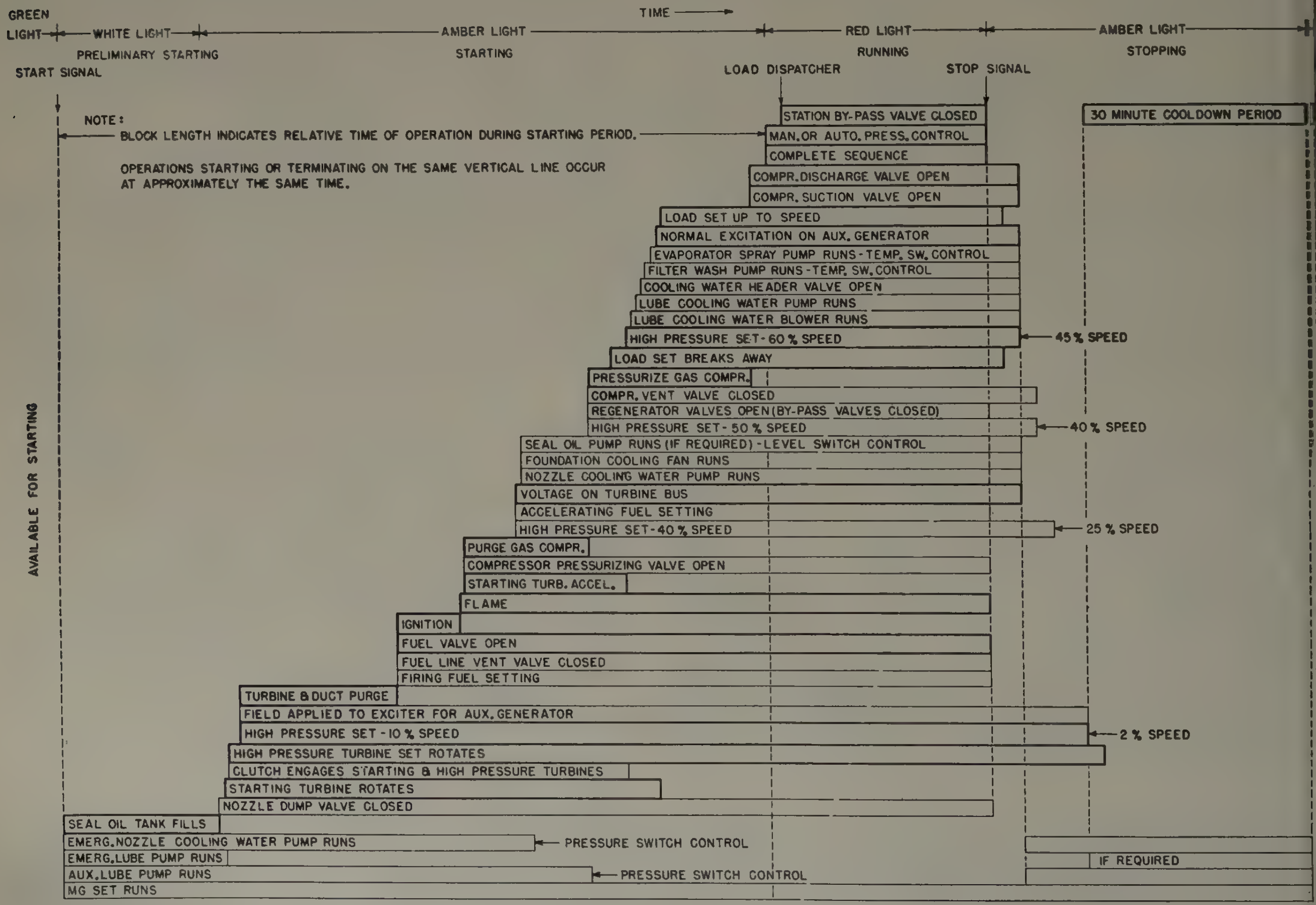

GREEN LIGHT
WHITE LIGHT
PRELIMINARY STARTING
START SIGNAL
TIME
AMBER LIGHT
STARTING
RED LIGHT
RUNNING
LOAD DISPATCHER
STOP SIGNAL
AMBER LIGHT
STOPPING
NOTE:
BLOCK LENGTH INDICATES RELATIVE TIME OF OPERATION DURING STARTING PERIOD.
OPERATIONS STARTING OR TERMINATING ON THE SAME VERTICAL LINE OCCUR AT APPROXIMATELY THE SAME TIME.
AVAILABLE FOR STARTING
30 MINUTE COOLDOWN PERIOD
STATION BY-PASS VALVE CLOSED
MAN. OR AUTO. PRESS. CONTROL
COMPLETE SEQUENCE
COMPR. DISCHARGE VALVE OPEN
COMPR. SUCTION VALVE OPEN
LOAD SET UP TO SPEED
NORMAL EXCITATION ON AUX. GENERATOR
EVAPORATOR SPRAY PUMP RUNS - TEMP. SW. CONTROL
FILTER WASH PUMP RUNS - TEMP. SW. CONTROL
COOLING WATER HEADER VALVE OPEN
LUBE COOLING WATER PUMP RUNS
LUBE COOLING WATER BLOWER RUNS
HIGH PRESSURE SET - 60 % SPEED
45 % SPEED
LOAD SET BREAKS AWAY
PRESSURIZE GAS COMPR.
COMPR. VENT VALVE CLOSED
REGENERATOR VALVES OPEN (BY-PASS VALVES CLOSED)
HIGH PRESSURE SET - 50 % SPEED
40 % SPEED
SEAL OIL PUMP RUNS (IF REQUIRED) - LEVEL SWITCH CONTROL
FOUNDATION COOLING FAN RUNS
NOZZLE COOLING WATER PUMP RUNS
VOLTAGE ON TURBINE BUS
ACCELERATING FUEL SETTING
HIGH PRESSURE SET - 40 % SPEED
25 % SPEED
PURGE GAS COMPR.
COMPRESSOR PRESSURIZING VALVE OPEN
STARTING TURB. ACCEL.
FLAME
IGNITION
FUEL VALVE OPEN
FUEL LINE VENT VALVE CLOSED
FIRING FUEL SETTING
TURBINE & DUCT PURGE
FIELD APPLIED TO EXCITER FOR AUX. GENERATOR
HIGH PRESSURE SET - 10 % SPEED
2 % SPEED
HIGH PRESSURE TURBINE SET ROTATES
CLUTCH ENGAGES STARTING & HIGH PRESSURE TURBINES
STARTING TURBINE ROTATES
NOZZLE DUMP VALVE CLOSED
SEAL OIL TANK FILLS
EMERG. NOZZLE COOLING WATER PUMP RUNS
PRESSURE SWITCH CONTROL
EMERG. LUBE PUMP RUNS
IF REQUIRED
AUX. LUBE PUMP RUNS
PRESSURE SWITCH CONTROL
MG SET RUNS

Figure 3. Control sequence diagram for pipe-line pumping gas turbine

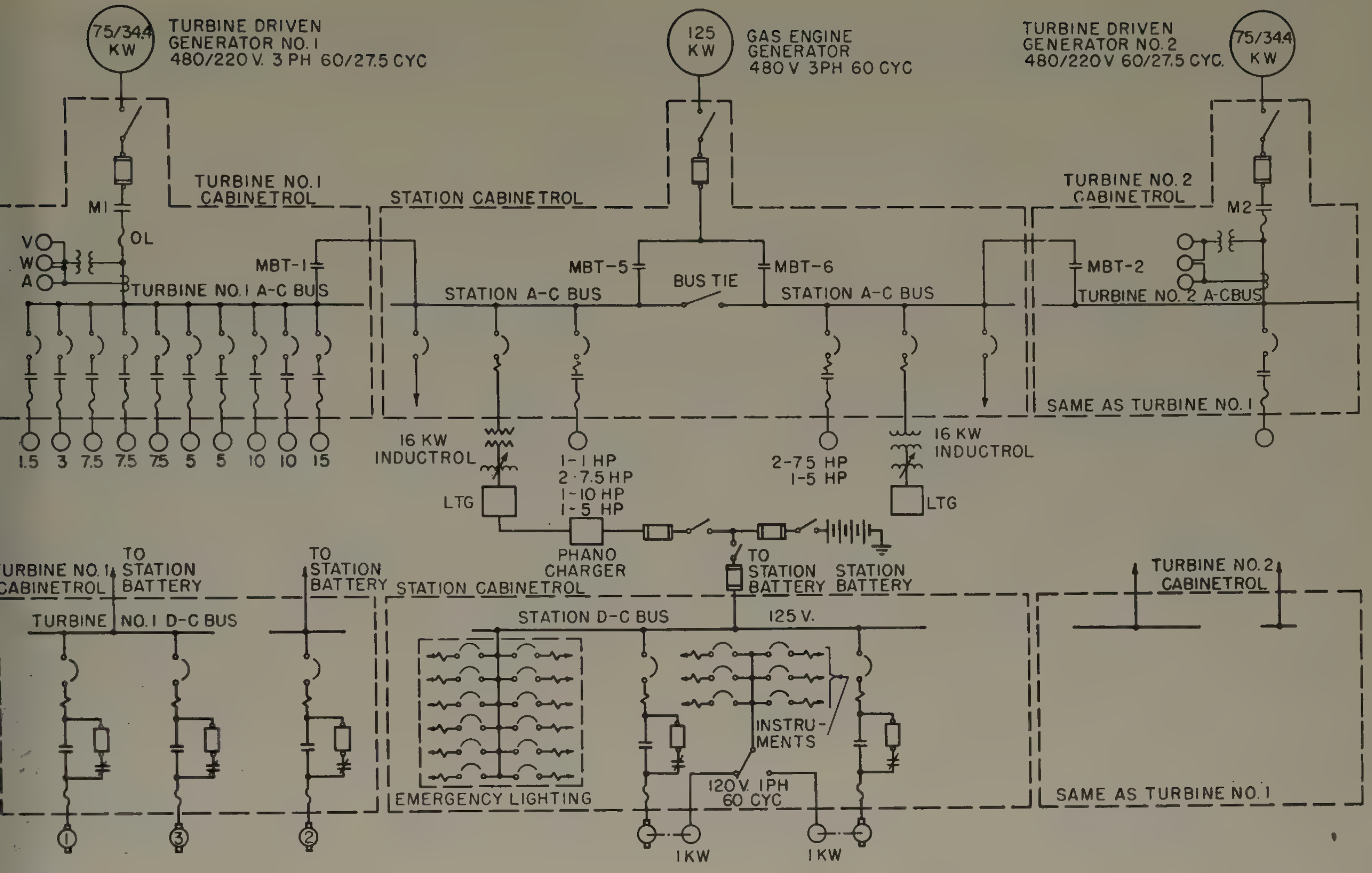


Figure 4. Single-line diagram of turbine and station auxiliaries for two 5,000-horsepower gas-turbine pipe-line pumpers

27.5/60 cycles on a constant volts-per-cycle basis. Since the generator frequency varies from 36 to 60 cycles from zero to full load of the gas compressor, and the voltage varies as the square of the speed on a self-excited machine, it is necessary to have a constant volts-per-cycle regulator. This regulator maintains the volts-per-cycle ratio constant to prevent overheating the squirrel-cage induction motors and also maintains constant volts (at any given frequency) with load. An exciter field rheostat mounted on the duplex control board provides manual voltage control of the auxiliary generator through a transfer switch which removes the constant volts-per-cycle regulator from service. During the period that the auxiliaries are being connected to the turbine bus, the generator is overexcited.

The Cabinetrol panel for the turbine auxiliaries consists of:

1. Turbine incoming-line fused switch, bus contactor, bus tie contactor, and associated relays.
2. A-c motor starters for the nozzle-cooling water pump, foundation cooling fan, compressor seal oil pumps, lube water cooling blowers and lube cooling water, filter wash, and the evaporator spray pumps.
3. D-c motor starters for the auxiliary and emergency lube oil and the emergency nozzle-cooling water pumps.

The Cabinetrol panel for the station auxiliaries consists of:

1. Feeders to Inductrol§ power packs (dry-type induction-voltage regulators) for regulating the lighting load.
2. A-c motor starters for the air compressors and control room ventilating fan.
3. Spare starters for the turbine auxiliaries.
4. Emergency lighting panels.
5. Control for two motor-generator sets which supply regulated a-c power for metering, recording, and ignition.
6. Master switching control for the power busses.

Here the maximum in flexibility is provided. In each station provision is made to supply:

1. The station busses from any one of the turbine busses.
2. Any turbine bus from the station busses.
3. One turbine bus from another via the station bus.

Complete interlocking is provided to prevent interconnection of any of the turbine generators since it is impossible to synchronize these machines under the varying turbine loads.

Each station panel has a mimic bus layout of the turbine and station busses with control switches and indicating lights for a 4-unit station. The indicating lights show the status of each circuit.

The possibility of completely automatic unattended gas-pipe-line pumping stations has been taken into consideration in the design of these panels. Only minor modifications would be required to install conventional supervisory equipment for remote control.

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§Registered trade-mark of the General Electric Company.

Microbiological Deterioration of Rubber Insulation

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O. S. PRATT

RESEARCH DEVOTED to developing rubber insulations resistant to micro-organisms has given two major results: 1. Compounds showing normal insulation resistance with no failures after 4 years in accelerated soil tests in which ordinary compounds fail in about 6 months; 2. Proof that the destructive organisms are fungi, and that these cause loss of insulation resistance and dielectric strength by growing through the insulation.

Unless made sufficiently fungitoxic both natural rubber and *GR-S* insulations are inherently vulnerable to fungus attack. More thorough mixing of the stocks may increase the life in the soil by 50 per cent, but the evidence to date is that permanent stability cannot be imparted by physical processing alone.

Certain butyl rubber compounds appear to be inherently stable, so that while there may be a few early localized failures the rest of the exposed sections have lasted for several years. Samples made with identical stock but with additional mixing on a laboratory mill have shown complete stability over similar periods. The weak spots in these butyl insulations thus appear to be "accidents" rather than a property of the bulk insulation. Nevertheless, as a guarantee of safety butyl rubber compounds also should be made fungitoxic.

The effectiveness of neoprene jackets as fungus barriers is greatly influenced by variations in mixing and extrusion, suggesting that ideal processing might make neoprene completely impassable to fungi. For safety, however, only fungitoxic insulations should be used even under neoprene jackets.

It has been shown that copper could be electrodeposited in micropores in failed insulation. Parallel electrical and microbiological tests revealed that these micropores were caused by certain fungi which are able to grow through the insulation. Replicate wire samples of various insulations were divided into two groups. One was tested for insulation resistance versus time in soil. In the corresponding group the conductor was pulled out and the resulting tubes filled with nutrient agar, sealed, sterilized, and buried in soil. After various periods, during which the wire samples had failed electrically, the agar was squeezed from the corresponding tubes and cultured. The results of the electrical tests and the culture tests agreed completely. Figure 1 shows agar rods squeezed from tubes of three insulations after 6 months in soil. The heaviest growth is from a typical natural rubber insulation, the medium growth from a somewhat vulnerable *GR-S* insulation, and the completely sterile rods from tubes of a stable fungitoxic *GR-S* insulation.

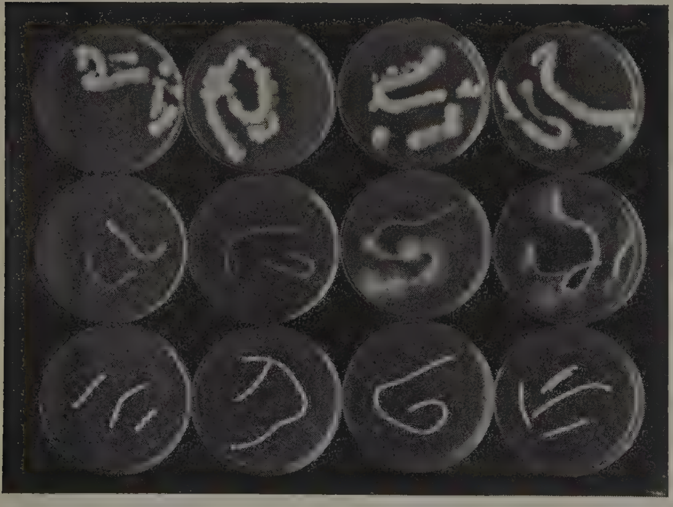

Figure 1. Cultures of agar squeezed from tubes of insulation after 6 months in soil. Top row, natural rubber; middle row, vulnerable GR-S; bottom row, stable GR-S

Apparently the number of types of fungi capable of penetrating rubber insulations is small. Although bacteria and actinomycetes can consume natural rubber slowly, electrical failures in all cases appear to be caused by fungi. Two predominant types found in this study were identified as: 1. Spicaria violacea Abbott; and 2. a Fusarium species.

These electrical and microbiological tests were combined successfully by pulling the conductor out of samples after they had failed electrically, filling with agar, and squeezing this out for culture after 1 week. Fungus was found inside the samples that had failed electrically. Blanks and also exposed samples that had not yet failed gave completely sterile culture plates.

Neither the insulation resistance test nor the culture test gives any indication of attack until fungus filaments have grown completely through. To show their presence in insulation before failure, slices were cut aseptically from the the interior of an 8/64-inch wall of *GR-S* insulation exposed 39 months to soil. When these slices were cultured, colonies of fungi, mostly Spicaria, clearly showed where fungus filaments were in the process of creating micropore failures.

Fungus filaments in insulation markedly decrease the dielectric strength even before the insulation resistance has dropped.

To be safe in soil, rubber insulating compounds need to be made sufficiently fungitoxic, without sacrifice of other necessary characteristics. Only such compounds should be used in underground cables not protected by metallic sheaths.

Digest of paper 53-59, "The Microbiological Deterioration of Rubber Insulation," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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D-C Amplifier Employing Junction-Type Transistors

EDWARD KEONJIAN

Some circuit arrangements for d-c amplifiers are described. Several methods for the solution of the drift problem are recommended. Some of the related operating characteristics of an experimental 2-stage amplifier are included.

THE SMALL SIZE of the transistor, its ruggedness, low power consumption, and long lifetime offer a great potential field of application, which includes the use of the transistor in d-c amplifiers. Unfortunately, at the present state of the transistor art, the operation of a d-c transistor amplifier is greatly affected by drift of the output current. This drift is caused primarily by changes in temperature of transistors since some of the parameters of transistors, like the collector impedance r_c, and particularly the collector current for zero emitter current, I_{co}, are very sensitive to temperature.

DIRECT-COUPLED AMPLIFIER CIRCUITS

DIRECT-COUPLED AMPLIFIERS commonly are used in a wide variety of applications. In many of these applications the signal may contain a d-c component as well as low-frequency components. Signals of this type are encountered in biology, medicine, cathode-ray techniques, square-wave testing, electronic switching techniques, and in many other control instruments and apparatus. Consequently this type of amplifier requires direct coupling between the stages without the use of coupling capacitors.

One possible arrangement of this type is shown in Figure 1 which consists of two grounded-emitter stages in which the signal developed across the load resistance r' of the first transistor is applied directly to the base of the second transistor. For proper operation of such an amplifier the direct voltage drop across resistance r' must be sufficient to maintain the emitter of the second transistor only slightly positive with respect to the base. An alternative arrangement consisting of a tandem arrangement of grounded-base and grounded-emitter stages, where the input impedance of the second stage serves as a load to the first stage, is shown in Figure 2. Still other arrangements can be devised and the number of cascaded stages can be increased to provide higher gain.

The analysis of the d-c amplifiers, as far as gain, amplification, and impedances are concerned, follows the general pattern of the audio transistor amplifier.

This analysis shows that in order to obtain maximum transducer gain, the first stage must be of the grounded-base connection, if r_g is very small. For intermediate values of r_g, the grounded-emitter connection is preferable, while for very large values of r_g, both of the connections, grounded-emitter and grounded-collector, could be used. For intermediate stages, the grounded-emitter connection gives maximum current amplification almost for any value of r_L, therefore this connection must be considered as typical for all intermediate stages. As to the output stage, the grounded-emitter connection is also "universal" for different values of r_L, although for very small values of r_L, the grounded-collector connection can be used also.

This analysis shows also that as far as the gain of a d-c amplifier is concerned, the current amplification factor of the transistor, a, is one of the most important parameters and consequently should be as high as possible.

Negative feedback as used in amplifiers usually improves their frequency response, linearity, and stability, therefore its use in the d-c transistor amplifier is especially desirable.

A very common arrangement of current feedback is shown in Figure 3 which is obtained by means of the resistance R in the emitter circuit of the transistor, and Figure 4 shows its equivalent diagram (grounded-emitter connection).

All the foregoing information would permit determining the performance of a d-c amplifier very well. However, the use of d-c transistor amplifiers is very much impeded by a number of factors among which the drift in the output current of the amplifier is most important. The following is concerned with this specific problem in d-c amplifiers.

PROBLEM OF DRIFT

DRIFT OF the output current of the d-c transistor amplifier is very pronounced. It easily occurs even when the input terminal of the amplifier is connected directly to ground and therefore cannot be attributed to thermal noise produced in an input resistor. Negative feedback cannot eliminate these changes because they act as if they were input signal variations and as such cannot be distinguished from the signal itself. The drift in d-c amplifiers is caused primarily by changes of temperature of the transistors, since most of the parameters of transistors vary with temperature. Figure 5 shows the variation of the transistor parameters with temperature for positive-negative-positive (p-n-p) junction transistors. However

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Condensed text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953, and recommended for publication by the AIEE Committee on Electronics.

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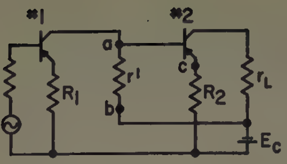


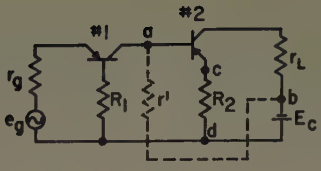
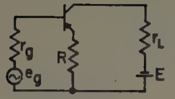


Figure 1 (left). **D-c amplifier with two grounded emitter stages.** **Figure 2 (right).** **Grounded-base grounded-emitter d-c transistor amplifier**



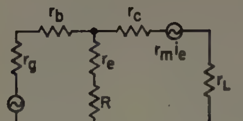


Figure 3 (left). **Single-stage grounded-emitter amplifier with negative feedback.** **Figure 4 (right).** **Equivalent diagram of the amplifier shown in Figure 3**

there is one more parameter, the "collector back current" I_{co} (that is, collector current for emitter current equals zero), which is particularly sensitive to temperature change. This parameter is related to the collector current of the transistor by the equation

$$I_c = \alpha I_e + I_{co} \tag{1}$$

where I_c is the collector current, I_e the emitter current, α the current amplification factor, and I_{co} collector back current. Figure 6 shows the variation of this parameter with temperature for several junction transistors. From these curves it can be seen that the current I_{co} can be expressed approximately as

$$I_{co} = I_s e^{0.05T} \tag{2}$$

where I_s is the current at 0 degrees centigrade and T the temperature in degrees centigrade. Hence

$$\frac{dI_{co}}{dT} = 0.05\ I_s e^{0.05T} = 0.05\ I_{co}$$

and the incremental change of this current can be written as

$$i_{co} = 0.05\ I_{co}\Delta T \tag{3}$$

where ΔT is the temperature change in degrees centigrade.

In general, the temperature coefficient for I_{co} is about 5 to 10 per cent per degree centigrade. In view of this, the temperature compensation of the d-c transistor amplifiers becomes a serious problem.

TEMPERATURE COMPENSATION OF D-C AMPLIFIERS

For temperature compensation of d-c transistor amplifiers several methods may be employed. One of these methods is based on the proper selection of the characteristics of the various transistors employed in the d-c amplifier. In order to analyze this method, consider the effect of temperature on the collector current in a single-stage transistor amplifier. The principal increment of the output current I_o of an amplifier due to the temperature change of the transistor is mainly that due to a change in the collector back current I_{co} and can be expressed by th equation:

$$i_o = S i_{co} \quad (4$$

where i_o is the increment of the output current of a amplifier, i_{co} is the increment of I_{co}, and S is the stabilit factor of the amplifier stage as defined in the appendix The expressions for S and for current amplification facto A_i, for three basic types of transistor amplifier connections are given in Figure 7 (provided that $r_L << r_c$). In thes equations R_e and R_b include all the resistances in thei respective circuits, internal as well as external to the transistor. For example, for a grounded-base connection:

$$R_e = r_e + r_g \quad (5$$

$$R_b = r_b + R_1 \quad (6$$

In a 2-stage amplifier the change in output current o the first stage (i_o) is amplified by A_{i2}, the current amplification factor of the second stage. Therefore the ne change in the output current of a 2-stage amplifier is

$$i_L = A_{i2} S_1 i_{co1} + S_2 i_{co2} \quad (7$$

where S_2 and i_{co2} are the stability factor and the increment of current I_{co} of the second stage respectively.

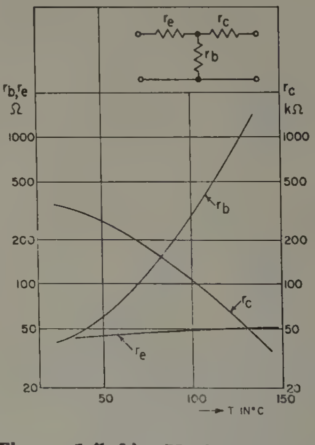
In order to obtain temperature compensation, the current i_L must be equal to zero:

$$A_{i2} S_1 i_{co1} + S_2 i_{co2} = 0 \quad (8)$$

If both transistors are of the same type (*p-n-p* or *n-p-n*) the currents i_{co1} and i_{co2} also will have the same sign and therefore, equation 8 will hold only if $A_{i2}S_1$ and S_2 have opposite signs. This condition is obtained if

1. $A_{i2} < 0$; $S_1 > 0$; $S_2 > 0$ (9)
2. $A_{i2} < 0$; $S_1 < 0$; $S_2 < 0$ (10
3. $A_{i2} > 0$; $S_1 > 0$; $S_2 < 0$ (11
4. $A_{i2} > 0$; $S_1 < 0$; $S_2 > 0$ (12

Temperature compensation also may be achieved if two transistors are of different types (one *p-n-p* and one *n-p-n*) In this case however, $A_{i2}S_1$ and S_2 must have the same sign Figure 8 shows one such circuit arrangement. Still other arrangements can be devised to satisfy equation 8.



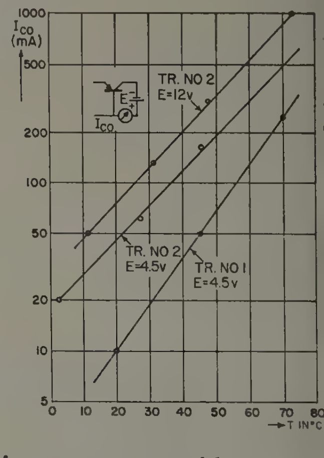
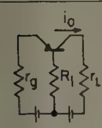
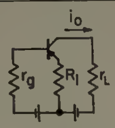
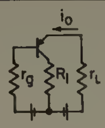


Figure 5 (left). **Variation of transistor parameters with temperature.** **Figure 6 (right).** **Temperature characteristic of I_{co}**

G.B.	G.E.	G.C.
		
$A_i \cong a$	$A_i \cong -\frac{a}{1-a}$	$A_i \cong \frac{1}{1-a}$
$S = \frac{R_e + R_b}{R_b(1-a)+R_e}$	$S = \frac{R_e+R_b}{R_e(1-a)+R_b}$	$S = -\frac{aR_e}{(1-a)R_e+R_b}$

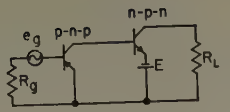


Figure 7 (left). Three basic connections of the amplifier stage. Figure 8 (above). A d-c amplifier using p-n-p and n-p-n transistors

If both transistors employed in the 2-stage amplifier are of the same type (*n-p-n* or *p-n-p*), only the following *five* connections can be used for temperature compensation of the amplifier

1. Grounded-emitter — Grounded-emitter
2. Grounded-base — Grounded-emitter
3. Grounded-base — Grounded-collector
4. Grounded-emitter — Grounded-collector
5. Grounded-collector — Grounded-base

The other four connections of all nine possible combinations, are *not* suitable for this type of temperature compensation. These four nonsuitable combinations are

1. Grounded-base — Grounded-base
2. Grounded-emitter — Grounded-base
3. Grounded-collector — Grounded-emitter
4. Grounded-collector — Grounded-collector

Depending on the requirements, any of the first five connections mentioned can be used for temperature compensation. For example, if the input resistance of the amplifier must be very low, connections 2 or 3 will be most desirable, while in order to have very high input resistance, connection 5 would be preferable.

However, this method of temperature compensation based on proper selection of transistor characteristics, is not entirely practical, since it requires transistors of the particular characteristics in each case. From this point of view, the following method of compensation, which utilizes the special temperature-sensitive elements in the circuit, is superior, since it does not require the selection of the transistors with proper characteristics and can be applied to any pair of transistors with standard characteristics.

In realization of the proposed method, the resistance r' in Figure 1, is replaced by the temperature-sensitive element such as junction diode, or some other element. By proper choice of the characteristic of this element, it will adjust the bias of the second transistor automatically so that the d-c collector current of this transistor remains constant as the ambient temperature varies.

Since the temperature affects almost all the parameters of transistors, as well as all external "permanent" resistors employed in the amplifier circuit, it would be very difficult to take all the factors which are due to temperature into account in order to calculate the proper characteristic of the afore-mentioned temperature-sensitive resistance. Therefore for simplicity, and greater accuracy also, this characteristic may be determined experimentally for any pair of transistors in the amplifier circuit. The procedure is as follows:

In the circuit of Figure 1, the resistance r' is replaced by a variable resistance. Then, for any given ambient temperature, the value of this resistance is adjusted so that the output current of the amplifier I_o remains constant. The plot of these values of resistance against temperature then will represent the desired temperature characteristic of the temperature-sensitive resistance. This means that a resistance having this temperature characteristic, being substituted for r', will maintain the output current I_o constant as the ambient temperature is changed. Figure 9 shows such a characteristic obtained experimentally for the 2-stage amplifier shown in Figure 2. The variable resistance r' was placed between the points *a-b* as shown. The parameters of the *p-n-p* junction transistors employed in the amplifier were

	α	r_c	r_b	r_e	I_{co}
Transistor *1*	0.96	1 megohm	600 ohms	20 ohms	6 microamperes
Transistor *2*	0.94	140,000 ohms	340 ohms	32 ohms	40 microamperes

The first set of curves (solid lines) were obtained with

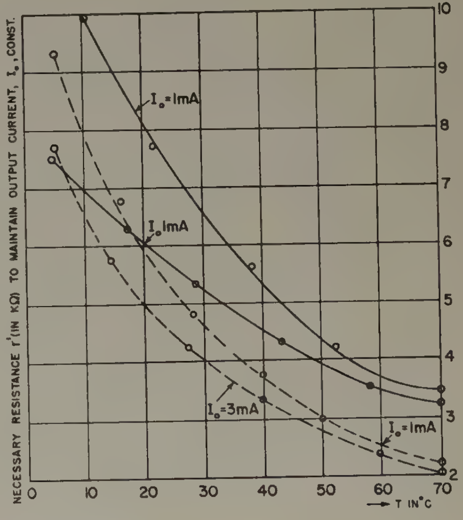
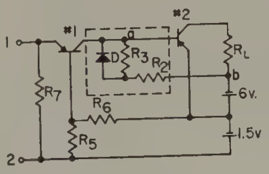


Figure 9. Temperature characteristics of resistance r′



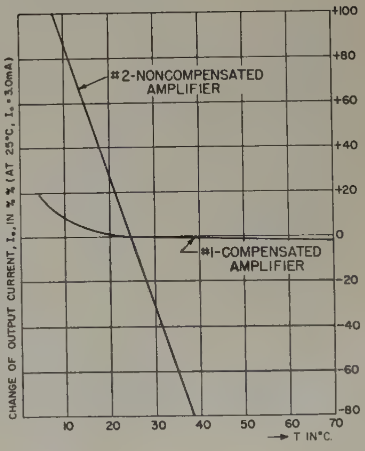


Figure 10 (above). Temperature-compensated amplifier employing a junction diode as a compensating element. Figure 11 (right). Temperature characteristics of amplifier

transistor *1* used in the first stage and transistor *2* in the second stage. The second set of curves (dotted lines) represents the case where the transistors are interchanged. In each case, the characteristics were taken for two constant values of output current I_o, 1 milliampere and 3 milliamperes. After the curves of the compensating resistance have been obtained, a suitable temperature-sensitive element must be found to replace resistor r' in Figure 1. A "suitable" resistance not only should have the required temperature characteristic, but also the same thermal time constant as the transistors used in the amplifier. If the last requirement is not satisfied, the chosen resistor will not respond to the temperature changes simultaneously with the transistors and therefore the amplifier will not be truly compensated. Another requirement for the compensating resistance is a low noise level.

Despite the fact that all the different types of commercially available temperature-sensitive resistors offer a great variety of characteristics, it is impossible to select among them a particular one, which would have exactly the same shape as required for complete temperature compensation of an amplifier. Therefore, for a practical application, the temperature-sensitive element must be used in the amplifier circuit in conjunction with a special "shaping" network which will change the characteristic of the temperature-sensitive resistance to that which is required for the compensation. Such a shaping network will consist of a number of parallel and series resistances.

In Figure 10, a circuit diagram of the temperature-compensated 2-stage d-c amplifier is shown. This arrangement utilizes the previously mentioned idea of temperature compensation by means of a junction diode *D*. The complete compensating network including the characteristic shaping resistors is indicated in the diagram by a dotted line.

The primary reason for the choice of the diode, in preference to other types of nonlinear resistors, was that the time constant of the available diode was similar to that of the transistors in the amplifier.

When a temperature-sensitive resistor is used in conjunction with a shaping network, it must have a greater rate of change of resistance with temperature than is required by the combination. From this standpoint, diodes are preferable, since their temperature coefficients are relatively high (5 per cent per degree at 25 degrees centigrade). Figure 11 shows the temperature characteristics of an experimental amplifier utilizing the circuit of Figure 10. Curve *1* shows the behavior of the compensated amplifier while curve *2* represents the noncompensated amplifier (with diode *D* removed and values of the resistors changed to maintain the output current, I_o, at its original value). Note the extreme change of output current, I_o, with temperature for the noncompensated amplifier: a temperature variation of less than 20 degrees centigrade is enough to produce a 100-per-cent change in output current. The curve representing the compensated amplifier is still far from ideal, but with the addition of one more resistance between points *a* and *b*, and by readjusting the shaping networks, the temperature characteristic of the amplifier may be improved further.

From Figure 9 it can be seen that the shape of th characteristic required for the compensating network depends greatly upon the initial value of the output current I_o. The smaller I_o becomes, the steeper must be th required compensating characteristic and conversely. Therefore, if the temperature characteristic of the amplifie shows some under- or over-compensation, this may b improved by a small resetting of the initial value of curren I_o.

Table I contains other parameters of the amplifier illustrated in Figure 10.

Table I. Operating Characteristics of the Amplifier

Input resistance	50 ohms (approximately)
Power gain	20 decibels (approximately)
Noise figure	40 decibels (approximately)
Minimum signal	50 microvolts (latest data are 10 microvolts
Maximum signal	50 microvolts
Dynamic range	40 decibels (latest data are 60 decibels)
Maximum drift at room temperature during 106 hours	Less than 1 per cent
Warm-up time	1 hour
Power consumption	25 microwatts

There are some other circuits which can be used in the d-c transistor amplifier to minimize the effect of the drift. Among these circuits is the complementary symmetry circuit which employs two *p-n-p* and two *n-p-n* transistors. However, there are still numerous problems which lie rather in the hands of the peope who make transistors than in the hands of circuit engineers. One very important problem of this kind is that of producing hermetically sealed transistors to minimize the effect of the moisture on their properties and hence on performance of the d-c amplifier.[1]

Appendix

Derivation of stability factor *S* for grounded-base connection (see Figure 12):

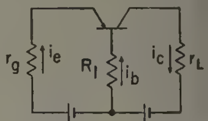


Figure 12. Grounded - base amplifier

$$R_e = r_e + r_g$$

$$R_b = r_b + R_1$$

$$i_c + i_b = i_c = \alpha i_e + i_{co}$$

$$R_e i_e = R_b i_b$$

$$i_e\left(\frac{R_e}{R_b}\right) + i_e = \alpha i_e + i_{co}$$

$$i_e\left(\frac{R_e}{R_b}\right) + i_e(1-\alpha) = i_{co} \qquad i_o = \frac{i_{co}}{\frac{R_e}{R_b}+(1-\alpha)}$$

$$i_c = \alpha i_e + i_{co} = i_{co}\left[1 + \frac{\alpha}{\frac{R_e}{R_b}+(1-\alpha)}\right]$$

$$= i_{co}\left[\frac{R_e + R_b(1-\alpha) + \alpha R_b}{R_e + R_b(1-\alpha)}\right]$$

$$= i_{co}\left[\frac{R_b + R_e}{R_e + R_b(1-\alpha)}\right] = i_{co}S$$

Reference

1. Principles of Transistor Circuits (book), **R. F. Shea.** John Wiley and Sons, Inc., New York, N. Y., 1953.

New Line of Power-Line Carrier Equipment

F. B. GUNTER
MEMBER AIEE

A NEW LINE OF carrier equipment with increased flexibility now has been designed to give more funcions in a given frequency spectrum under operating condiions encountered in the field. The new line of apparatus ncludes frequency shift equipment, relaying equipment, and communications equipment.

The frequency shift transmitters and receivers in the new apparatus are crystal controlled and have very high selectivity to permit maximum utilization of the carrier spectrum. They are suitable for telegraphic functions such as telemetering, supervisory control, remote and transfer trip, and load control. The narrow bandwidth occupied and the high channel attenuation capability of these units permits their use at points in the frequency spectrum on a given power system where suitable.

The transmitter and receiver are both capable of operation from either 120 volts alternating current or 60-cell station batteries. The transmitter output is 2 watts and the receiver sensitivity is great enough to give an ultimate system channel capability, in the absence of noise, of approximately 90 decibels. A new type of modulator in the transmitter permits constant 120-cycle shift of carrier frequency, at any frequency from 40 to 200 kc, for increased speed of operation and greater freedom from noise. Filter and discriminator crystals available today for receivers limit the useable shift to 0.15 per cent below 65 kc; but full 120-cycle shift is maintained at higher frequencies.

Standard relaying assemblies are available for both distance and phase-comparison relaying, for indoor or outdoor installation, with and without push-to-talk communication, with and without filament failure alarms, and for both 60- and 120-cell station batteries.

The new line includes distance relaying assemblies for both circuit-opening carrier start and circuit-closing carrier start operation. In these assemblies, an improved design of relay receiver permits operation over 40-decibel channels and provides faster operation with more than ample relay blocking current. For an internal fault, the time required from carrier-stop element operation at one terminal until the blocking current at other terminal drops to 3 milliamperes is approximately 10 milliseconds.

The new phase-comparison relaying assemblies include an improved design of electronic relay control unit. This control unit uses no thyratron tubes and provides a phase-shift delay adjustment to permit the phase delay introduced by the equipment and the transmission line to be compensated.

The relaying transmitter includes output filters to minimize harmonic and other spurious output and also includes a continuously adjustable output control to enable the transmitter to be operated below its normal output of 10 watts where such operation is desirable to minimize adjacent channel interference. The relay receiver also includes a new design of sleet or performance test which permits easy reading, directly in decibels, of the channel attenuation and equipment performance.

Relaying assemblies with voice communications have high-quality frequency-modulated push-to-talk communication which may be used with telephone extensions remote from the carrier set.

Voice communications is an important facility in the day-to-day operation of an electrical utility system. During periods of emergency, it becomes doubly essential that the voice communications be as dependable as the power transmission system itself. To insure complete independence from loss of communications during a-c power failure, the new line of equipment is designed for operation from station batteries.

The new line of voice communications apparatus includes single-frequency (simplex) assemblies, with both manual or automatic control of carrier, and 2-frequency (duplex) assemblies. Code bell or dial selective calling is available. The apparatus provides ringing voltage for both 60- and 20-cycle bells in either common battery or local battery telephones. The dial selective assemblies include a complete automatic switchboard, which uses the carrier circuit as a trunk between stations, and provides busy signals, revertive ringback, and other features of commercial dial-telephone systems.

The nominal transmitter output is 10 watts and the receiver sensitivity permits operation, in the absence of noise, over channels with greater than 90 decibels attenuation. The transmitter input circuit contains input filters which attenuate signals of 60 cycles or 4,000 cycles by 30 decibels or more so that only essential modulating frequencies are transmitted. The receiver input circuit contains high-selectivity filters which attenuate undesired signals 8 kc away by 90 decibels or greater.

For best intelligibility, the audio response of a complete system, comprising transmitter and receiver, is flat within 6 decibels from 190 to 3,150 cycles. The audio circuits permit full modulation with telephone extensions of up to 20 decibels attenuation at each terminal of a system. The duplex assemblies include a new design of electronic 4-wire terminating or "hybrid" which gives greater return loss (signal level at a remote telephone extension) for a given amount of unbalance of the circuit. The automatic simplex assemblies include a new design of electronic transfer unit with an anticipator circuit which minimizes the transients or clicks which have been objectionable in previous designs.

Digest of paper 53-166, "A Flexible New Line of Power-Line Carrier Equipment," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Integrating Instruments for Quality Control

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IN QUALITY-CONTROL work, it is often necessary to determine the mean and the standard deviation of an important parameter, such as a dimension of the product. To accomplish this, a measurement system called an Evenness Integrator, Figure 1, has been developed for applications in which the material is tested while moving continuously. Since most of the necessary calculating functions are performed by two new integrating instruments, the equipment eliminates virtually all of the laborious data-taking and the computations ordinarily associated with the statistical analysis of a large number of discrete measurements.

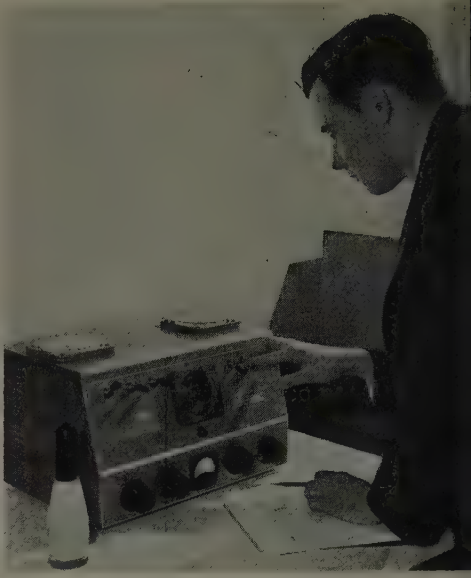

Figure 1. Evenness integrator

Although developed primarily for measuring the thickness of yarn, sliver, and roving in the textile industry, this integrating system presumably could be applied to other materials such as paper, metal strip, wire, or plastics, which can be tested while moving at constant speed.

The principle of testing materials while in motion, although not new, has certain particular advantages in quality-control measurements. Large samples can be tested economically, and furthermore, the system responds continuously to the varying dimension throughout the length of the sample, a matter of statistical importance, corresponding to an almost infinite number of discrete measurements.

There is a testing device known as the Pacific Evenness Tester, widely used in the textile industry, which records the thickness of yarn, sliver, or roving as it passes between two rolls at 12 yards per minute. This tester and the Evenness Integrator form a complete system for the recording and integration of thickness. It is important that the mean thickness of yarn conform to certain standards, and furthermore, the degree of variation ("unevenness") is another significant criterion of quality, the standard deviation being a good measure of this characteristic.

To determine these two statistics, two new end-devices are provided. The first, a d-c current-integrating instrument, measures the mean thickness deviation from a preset value. The second, an a-c current-squared integrating instrument, measures the mean-square of the thickness deviation. The standard deviation (σ) is obtained readily from a nomograph designed to solve the relation $\sigma=\sqrt{B-A^2}$, where A is the reading of the current integrator and B the reading of the current-squared integrator.

As the material passes between the two rolls, the upper one, which is movable, actuates an electric dimension gauge through a linkage that includes a micrometer screw, which is preset to the approximate thickness expected of the material, deviations being measured with respect to this preset value. The dimension gauge, which is of the 2 coil variable-inductance type, is connected in an impedance bridge circuit, providing an alternating voltage varying in phase and magnitude according to the thickness deviation from the preset value. This alternating voltage is amplified by an electronic amplifier, which drives the recorder in addition to the integrators.

The current-integrating instrument, used in combination with an a-c to d-c converter, is a permanent-magnet moving-coil milliammeter having a very high degree of damping and extremely small restoring torque, so that the speed of pointer motion varies according to the instantaneous current value. The pointer is set to zero before beginning a test, the final pointer position at the end of the test indicating the integral of the current.

The a-c current-squared integrator is an electrodynamic instrument with a fixed field coil and a moving coil in series, with a very high degree of damping and an extremely small restoring torque. Since the speed of pointer motion varies as the square of the current, the final pointer position indicates the integral of the current squared.

Also included in the system is a timer and relays which connect the integrators to the circuit upon starting the measuring cycle and disconnect them at the end of a definite interval. When disconnected, the instruments stop immediately, after which the operator records the readings. Reset controls are included to set the instruments to zero before starting a new test.

The Evenness Integrator has been applied successfully to textile materials ranging from 0.004 to 0.060 inch in mean thickness, with standard deviations from 0.001 to 0.012 inch. The usual integrating time is 2 minutes, although shorter intervals can be used also.

Digest of paper 53-205, "Integrating Instruments for Simplified Quality-Control Measurements," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Lightning Protection in Extra-High-Voltage Stations

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MEMBER AIEE

This analogue computer study was made of a 330-kv substation to learn whether a lightning arrester had to be applied to each transformer or whether one arrester would protect the pair of transformers supplied by each bay.

THE BEST PROTECTION of electric equipment against surge voltages is obtained by mounting a lightning arrester as close to the protected equipment as clearances permit. Careful analysis is required to insure that arrester locations are selected to provide the best over-all protection. The natural tendency of station circuits to reduce the magnitude of surges which enter the station is an important consideration in the application of lightning arresters. At extra-high voltages where station equipment and structures are physically large with numerous tap connections and capacitances, this factor becomes especially significant. Analogue computer (anacom) studies are of inestimable value in showing the influence and importance of circuit configuration toward the reduction of surge voltages within the station. A previous paper[1] on this subject described the method of analysis and gave the results of an anacom study in which a simple 1-source supply with one outgoing feeder was selected for basic analysis. That study demonstrated that considerable reduction in the magnitude of surge voltages, with corresponding decrease in stress on equipment insulation, resulted from the addition of a second transmission line into the station.

In the 330-kv substation selected for analysis, with the usual application of a lightning arrester on each transformer, complete protection of all equipment in the substation could not be assured because of the greater dimensions inherent in the switching structure for this voltage. In this station, the problem was complicated further by the arrangement of two transformers served from one circuit breaker position. Reduced to simplest terms, it was necessary to know if an arrester must be applied to each transformer or whether one arrester would protect the pair of transformers supplied by each bay. There was also the possibility that arresters might be necessary on each transmission line at the station entrance as well as at the transformers.

This study was set up as an extension of a previous investigation[1] in which a simple 1-source supply with one outgoing feeder was selected for basic analysis. The principal assumptions upon which the first study was made also were applied to this one. The most important single assumption is that all surges come into the station over the feeders, or overhead lines, as traveling waves. It also was assumed that a 1,175-kv basic impulse insulation level would be used for all equipment.

SUBSTATION LAYOUT

THE 330-KV SUBSTATION for which this study was made makes use of the "breaker and one-half" scheme as indicated by the single-line diagram shown in Figure 1.

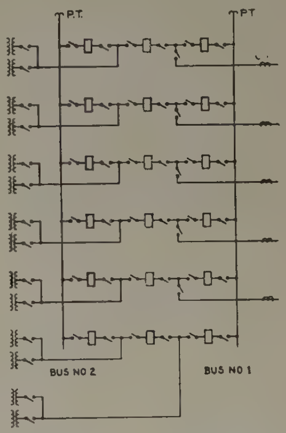

Figure 1. Single-line diagram of station used in study

One-line diagrams for circuits used in the study are shown in Figures 2–5 on which are denoted approximate lengths in circuit feet between points. Numbers in the circles on the figures identify metering points. One case, Figure 2, considered only bay number *1* with no connected bus structure except the limited length out to the potential transformer locations. This circuit is the arrangement which would be used if lightning arresters are employed adjacent to both transformers in each bay at metering points *6* and *8*. The circuit in Figure 3 shows an alternate arrangement which would be adopted if only one lightning arrester were employed at metering point *11* to protect both transformers.

APPLIED WAVESHAPES

THE PHILOSOPHY attending the selection of waveshapes used in the first study of protection of extra-high-voltage stations has been covered in detail elsewhere[1] and therefore is treated only briefly here. The characteristics of the surges used in that study were arrived at through the use of the following constants:

1. Tower footing resistance, 10 ohms.
2. Tower inductance, 20 microhenrys.
3. Coupling factor between ground wire and phase conductor, 25 per cent.
4. Shape of stroke current wave, 4×40 microseconds.

Condensed text of paper 53-241, "Lightning Protection in Extra-High-Voltage Stations—Influence of Multiple Circuits," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Operations Committee for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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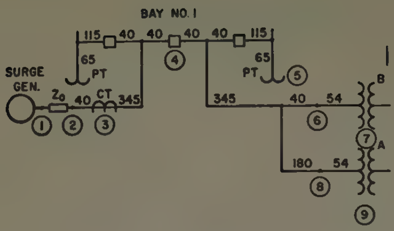


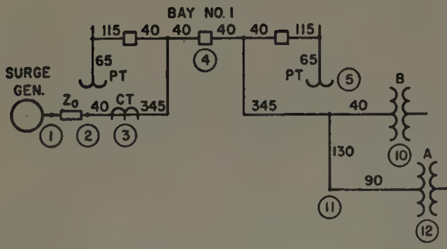


Figure 2 (top). Anacom 1-line diagram showing bay number 1, permitting installation of lightning arresters adjacent to each transformer. **Figure 3 (bottom).** Alternate anacom 1-line diagram showing bay number 1, permitting a single lightning arrester to protect both transformers

Circled numbers identify metering points; other numbers show circuit feet between junctions

5. Number of insulators per string, 18 $5\frac{3}{4}$-inch units.

Classified according to time to decay to half-crest magnitude, these constants give rise to three general classes of waves: short-tail, chopped, and full.

1. Short-tail waves result from high-current strokes to the shielding system followed by an insulator string flashover which raises the phase conductor up to tower-top potential. The resultant voltage wave may be approximated by a surge of 1,600-kv crest magnitude, the flashover voltage of the insulator string, which decays exponentially to half value in 10 microseconds.
2. Waves chopped on the front result from strokes directly to the phase wire of sufficient magnitude to flash over the insulation to the tower.
3. Full waves are created by strokes directly to the phase wire of such low current that the insulation does not flash over to ground, permitting a long-tail surge to travel along the transmission line. The magnitude of such a surge is limited to the full-wave insulation level of 18 insulators, or 1,600 kv, and the tail is the same length as that of the stroke current, assumed to be 40 microseconds.

The present study was limited to two of the general classes of surges: short-tail waves were selected because these occur most frequently; full waves were selected because these are the most destructive. Fronts of lightning surges are sloped off by corona and resistive losses as they travel along the transmission line. Two rates-of-rise were used for each class of surge, namely 500 and 1,000 kv per microsecond. The former value has been used in previous studies[2,3] and found to give results consistent with experience. The four waveshapes used in the present study are tabulated in Table I where wave numbers correspond to numbers used in the first study[1] in order to make it easier to compare the two cases.

USE OF THE ANACOM

The analogue computer is a powerful device for handling transient phenomena in networks where analytical methods are hopelessly complicated or virtually impossible. Basically the principle is to set up the network in miniature on the computer, using an appropriate time base and an impedance multiplier. To the computer circuit a low-voltage surge is applied repetitively in order to make the surge voltages appear as standing waves.

Table I. Waves Assumed to Approach Switching Station Over Phase Conductor

Wave Number	Type	Caused by	Crest Voltage, Kv	Rate-of-Rise of Front, Kv per Microsecond	Time to Half-Value Microsecon
2	Short tail	*	1,600	500	10
3	Full	†	1,600	500	40
5	Short tail	*	1,600	1,000	10
6	Full	†	1,600	1,000	40

* Stroke to shielding system and insulator flashover.

† Stroke to conductor and no insulator flashover.

The basic circuit used in the anacom study is shown in Figure 6*A*. A detailed schematic diagram of the lightning-arrester analogue is shown in Figure 6*B*. Gap action was simulated by closing switch S_3 at the instant the voltage at the arrester location reached the sparkover value of the arrester gap, a value assumed to be 1,000 kv regardless of the rate-of-rise of the applied surge. This assumption is slightly conservative but removes a minor variable from the problem. Nonlinear discharge characteristics of the lightning arrester were obtained through use of the rectifier circuit. Discharge characteristics of the analogue and of a 258-kv station-type lightning arrester subjected to 10×20-microsecond current surges are shown in Figure 7. It was not possible, with the analogue used, to obtain the lower part of the volt-ampere curve of the lightning arrester. Conservative results were obtained on this account since voltages at the arrester location were held higher on the end of the surge by the analogue than would be the case on the system.

Voltages between any two points of the anacom circuit may be measured easily with an oscilloscope and oscillograms obtained as desired. Each of the four basic cases selected for study was set up on the anacom and the waves listed in Table I were applied. It was possible on the analogue circuit to connect lightning arresters at any of the metering points, identified by circled numbers in Figures 2–5, and various combinations were investigated. Oscillograms of the resultant voltages were taken at selected metering points.

ANACOM DATA

Surge voltages from the oscillograms have been expressed in terms of severity index.[1] This procedure is based on the integration method of evaluating the disruptive effect of nonstandard waves in terms of equivalent standard test waves.[2,3] The severity index of any given waveshape is defined as the crest voltage of a standard $1\frac{1}{2}\times 40$-microsecond wave which has the same disruptive effect as does the given wave. It is convenient to express this voltage in per cent of the peak magnitude of a standard $1\frac{1}{2}\times 40$ wave which the insulation can withstand, thereby obtaining a per cent severity index.

This study has given consideration to the disruptive effect of surges on two kinds of insulation: porcelain and transformer internal insulation. Severity indexes of surges on porcelain were expressed in terms of the external portion of 330-kv bushings having the 1,175-kv basic impulse insulation level withstand curve of Figure 8. Any wave which just will stress the bushing to this curve has a severity index of 100 per cent on porcelain; for example, either a 1,600-kv $1^{1}/_{2}\times 40$ wave chopped at 3 microseconds or a 1,300-kv $1^{1}/_{2}\times 40$ wave chopped at 7 microseconds. Severity indexes of surges on the power transformers were expressed in terms of the standard impulse tests for 1,175-kv basic impulse insulation level internal insulation. Therefore, either a 1,350-kv $1^{1}/_{2}\times 40$ wave chopped at 3 microseconds or a 1,175-kv $1^{1}/_{2}\times 40$ full wave has a severity index of 100 per cent on the transformer internal insulation.

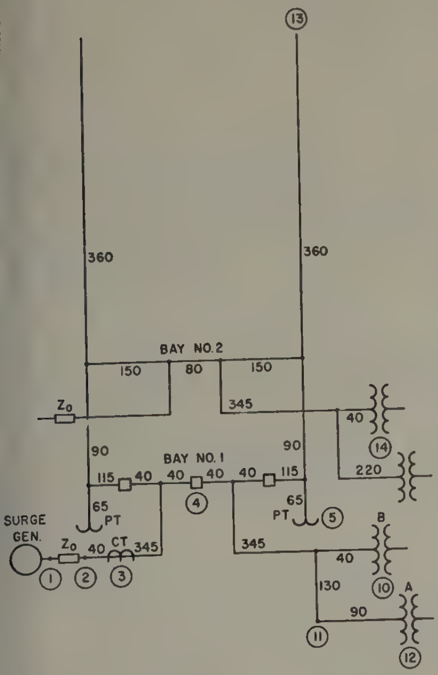
Attention was directed first toward the determination of the number of arresters required to protect the two transformers in each bay. Wave 2 of Table I was applied to the circuit of Figure 2 with lightning arresters connected only at metering points *6* and *8*. Then the same wave was applied to the circuit of Figure 3 with a single lightning arrester connected at metering point *11*. The severity indexes are tabulated in Table II. Since a single lightning arrester at junction point *11* provided adequate protection for both transformers, this arrangement was used in all other tests.

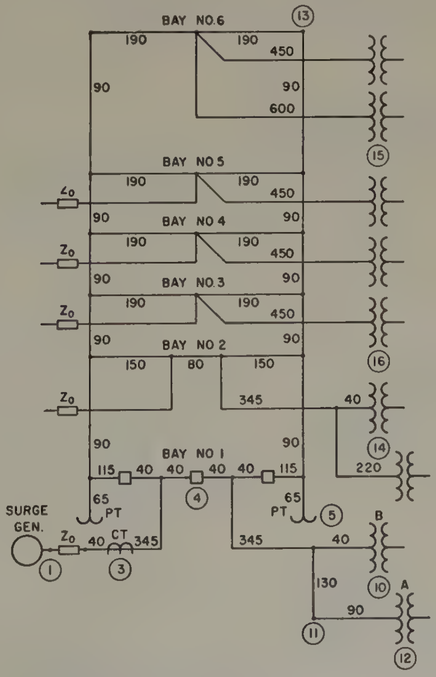
The second case in the study consisted of applying in turn each of the waveshapes tabulated in Table I to a single bay, shown in the circuit diagram of Figure 3, with several combinations of lightning arresters. Severity indexes are tabulated in Table III, the lightning arrester locations being identified by an X placed in the appropriate column. These show that the transformers were not protected adequately by a single lightning arrester located on the transmission line at the station entrance. However, a single arrester located at the junction between the two transformers, metering point *11*, did provide good protection for both transformers. This arrangement permitted voltages as high as 1,200 and 1,400 kv at the current transformer and potential transformer locations, respectively. These surges, however, were of short duration and could be tolerated, as indicated by the severity index at these locations.

The third case differed from the second only by the addition of bay number *2* and the station busses to the circuit, as shown in Figure 4. Oscillograms were not made with line arresters for waves 2 and 5 since it was observed that the voltages were too low to spark over an arrester at this location. Severity indexes of resultant voltages are tabulated in Table IV. These show a remarkable reduction in severity of surge voltage from the corresponding point with only one bay in service. However, with full waves 3 and 6 applied the reduction in voltage was not sufficient to permit the omission of arresters.

In the last case, the whole station was set up on the anacom as shown in Figure 5. No arresters were employed since surge voltages were not high enough to spark over an arrester at any point in the station. Severity indexes of surge voltages at the metering points are tabulated in Table V. Comparison with those obtained with one bay and two bays in service illustrates the effectiveness of multiple circuits in reducing the severity of surge voltages.

Oscillograms of surge voltages taken at transformer *A*, metering point *12*, with no lightning arresters connected and with various portions of the station in service are shown in Figure 9. These oscillograms and the severity indexes, given with each figure, show the striking reduction





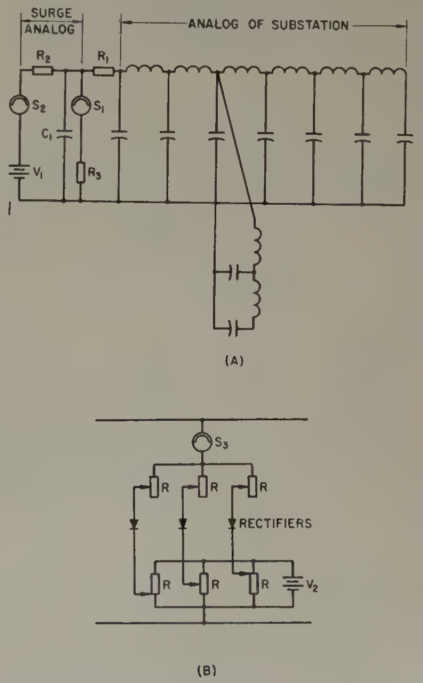
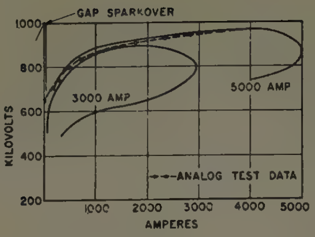


Figure 4 (left). **Anacom 1-line diagram with two bays in service.** **Figure 5 (center).** **Anacom 1-line diagram with the whole station in service.** **Figure 6 (right).** **A. Basic anacom circuit; B. Lightning arrester analogue**

Circled numbers identify metering points; other numbers show circuit feet between junctions



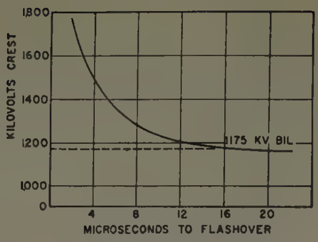


Figure 7 (left). Volt-ampere characteristics of a 258-kv station-type lightning arrester with test data from the lightning arrester analogue indicated. Figure 8 (right). Impulse withstand curves for the external porcelain of 330-kv bushings

in surge voltages as the number of circuits connected to the bus is increased.

In Figure 10, oscillograms of surge voltages at transformer *A* with only one bay in service and with wave 6 applied are shown for arresters at several different locations. These show that adequate protection of the transformers is not provided by a single lightning arrester on the line but is provided by a single arrester at the junction point between the two transformers in each bay.

DISCUSSION OF STUDY

A REVIEW OF the voltages recorded at various locations in the substation indicates how much the voltages are affected by the dimensions and arrangement of the circuits, and especially the significant effect of reflection points. A lightning arrester located only on the line, a metering point *2*, limited the voltage entering the substation to 1,000 kv, but in a single bay this surge can reflec from the transformer to produce voltages as high as 1,60 kv, which cannot be tolerated. This is shown conclusively in Table III; the severity indexes at the transformers are consistently higher than those near the entrance to the station.

With only a single bay in service, an arrester only at the transformer junction held the voltage at that point to 1,000 kv but permitted 1,200 kv at the line terminal. This voltage can be tolerated because the equipment can stand more than its basic impulse insulation level rating if the surge is of short duration. In this case, since the wound-type current transformers were deleted from the design, no equipment of this type was subjected to this voltage. This same condition resulted in a reading of 1,400 kv at the bus potential transformers. It will be noted that with the circuits represented in a single bay, the bus potential transformers were at the end of a radial tap extending from a point between the line entrance and the transformer, and this tap is sufficiently long to permit an appreciable reflection of the surge. With the entire bus and more circuits in service, this surge divided and did not reflect dangerously at these potential transformers. For this reason it was decided that, if operation of a single bay became desirable during lightning season, arresters should be installed temporarily at the potential transformers.

The addition of the second and subsequent bays ap-

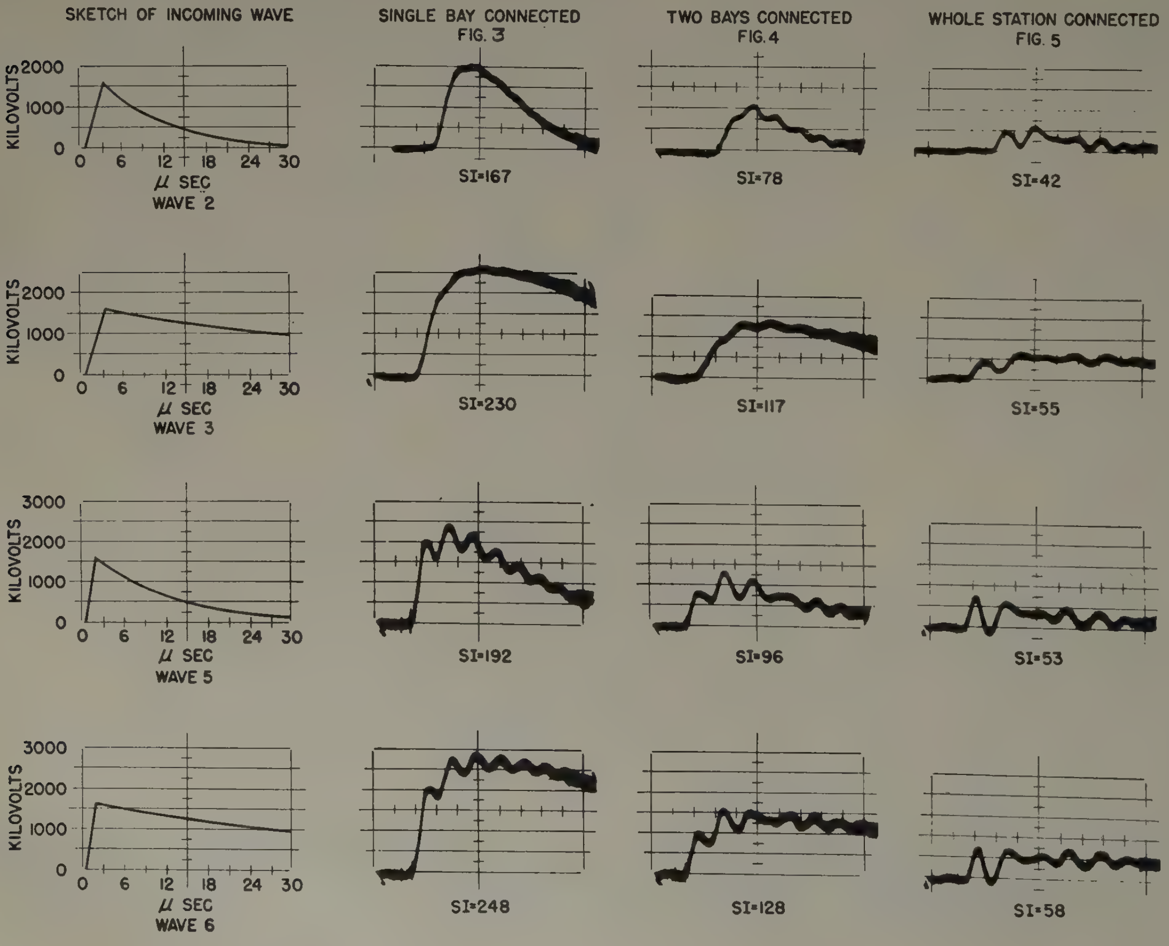


Figure 9. Oscillograms of surge voltage at transformer A (metering point 12) with no lightning arresters connected. Severity indexes shown are based on internal insulation

Table II. Comparison of One Transformer Lightning Arrester to Two Made With Wave 2, No Line Arrester

		Per Cent Severity Index on Porcelain							Per Cent Severity Index on Internal Insulation			
Lightning Arrester Location	Circuit	Current Transformer (3)	Oil Circuit Breaker (4)	Potential Transformer (5)	Transformer A (9)	Transformer A (12)	Transformer B (7)	Transformer B (10)	Transformer A (9)	Transformer A (12)	Transformer B (7)	Transformer B (10)
Each transformer (6), (8)	Figure 2	63	62	68	59		57		66		64	
Junction only (11)	Figure 3	72	77	77		63		64		71		72

Table III. Comparison of Severity Indexes Single Bay Connected (Figure 3)

	Lightning Arrester Location§		Per Cent Severity Index on Porcelain						Per Cent Severity Index on Internal Insulation	
Wave	Line (2)	Junction (11)	Current Transformer (3)	Oil Circuit Breaker (4)	Potential Transformer (5)	Transformer Arrester (11)	Transformer A (12)	Transformer B (10)	Transformer A (12)	Transformer B (10)
2			138	148	148	150	150	150	167	167
2		X	72	77	77	61	63	64	71	72
2	X		63	82	82	88	89	88	113	113
2	X	X	55	57	62	55	57	58	69	70
3			215	215	215	227	227	227	230	230
3		X	87	86	91	76	77	79	81	83
3	X		71	88	89	105	106	105	115	114
3	X	X	60	71	82	64	66	67	76	77
5			162	163	165	164	166	164	192	191
5		X	65	73	76	61	64	66	75	77
5	X		58	81	83	101	102	100	125	123
5	X	X	59	64	68	56	58	60	66	68
6			238	237	241	242	242	241	248	248
6		X	89	87	89	75	77	79	82	84
6	X		75	91	90	116	117	115	133	131
6	X	X	66	69	74	69	70	72	79	80

§ Installations only in locations designated by X

Table IV. Comparison of Severity Indexes Two Bays Connected (Figure 4)

	Lightning Arrester Location‖		Per Cent Severity Index on Porcelain								Per Cent Severity Index on Internal Insulation	
Wave	Line (2)	Junction (11)	Current Transformer (3)	Oil Circuit Breaker (4)	Potential Transformer (5)	Transformer Arrester (11)	Transformer A (12)	Transformer B (10)	2d Bay (14)	End of Bus (13)	Transformer A (12)	Transformer B (10)
2			64	67	68	71	71	71	69	69	78	78
2		X	52	59	63	63	66	64	67	65	72	70
3			110	109	109	107	107	107		77	117	117
3		X	74	77	79	69	69	70		79	71	72
3	X		66	76	77	86	86	87	78	77	98	98
3	X	X	63	70	70	62	62	63	75	70	66	67
5			70	76	76	88	89	88	81	76	96	96
5		X	63	61	64	59	59	59	79	72	63	63
6			122	121	121	125	126	125	118	120	128	127
6		X	79	78	79	69	70	71	80	81	76	77
6	X		70	77	78	87	88	86	86	84	98	97
6	X	X	68	77	78	73	74	74	84	78	80	80

‖ Installations only in locations designated by X

Table V. Comparison of Severity Indexes Whole Station Connected (Figure 5)—No Lightning Arresters

	Per Cent Severity Index on Porcelain										Per Cent Severity Index on Internal Insulation	
Wave	Current Transformer (3)	Oil Circuit Breaker (4)	Potential Transformer (5)	Transformer Arrester (11)	Transformer A (12)	Transformer B (10)	2d Bay (14)	3d Bay (16)	6th Bay (15)	End of Bus (13)	Transformer A (12)	Transformer B (10)
2	32	30	30	36	36	36					42	42
3	44	43	43	50	50	50	39	52	46	55	55	55
5	53	31	32	47	47	46	42	40	45	39	53	52
6	56	47	47	55	55	54	47	49	49	48	58	57

preciably reduced the surge voltages measured until, with the entire substation, the surge was divided into so many paths that the highest value recorded was about 800 kv. This might indicate that no lightning arresters are necessary as long as the entire substation is intact; but good judgment dictates that the transformers should be protected for any unusual situation and arresters should be applied to the transformer bus.

Comparison of a lightning arrester on each transformer against one arrester for a pair of transformers was made with a single bay in service, the most severe case. With the former arrangement, good protection was provided. With the arrangement modified to locate an arrester at the junction between the two transformers adequate protection was still provided.

It was assumed that the substation and the connecting

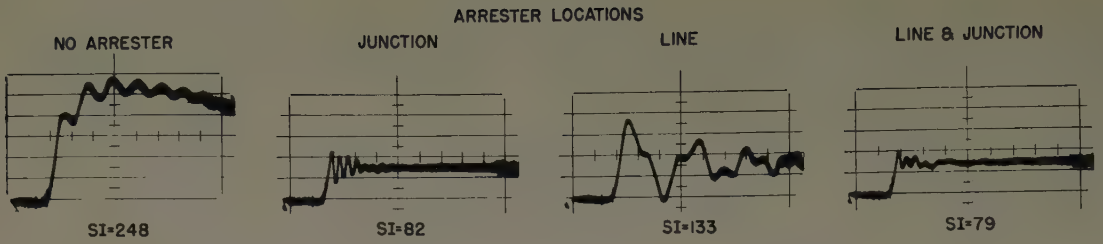


Figure 10. Oscillograms of surge voltages at transformer A (metering point 12) with only bay number 1 connected and wave number 6 applied. Severity indexes based on internal insulation

lines would be provided with adequate shield wires and low-resistance grounds so that direct strokes to the phase conductors with resulting full-wave surges would be very unlikely. However, some tests were made using full waves instead of short-tailed waves. These resulted in slightly higher voltages at some points in the substation, but not enough higher to change the recommendation of one lightning arrester for each pair of transformers.

CONCLUSIONS

This study has resulted in the following conclusions:

1. Adequate surge protection for the transformers in this substation will be provided by using one set of lightning arresters for each pair of transformers, keeping the transformer leads as short as possible, in this case about 150 feet.
2. With this arrangement, no additional arresters will be required on the lines or on the busses.
3. With two or more bays in service, surge voltages at various points within the station are reduced considerably over those experienced in a single bay.
4. This study has demonstrated that with several bays in service, a dangerous surge voltage in the substation is very unlikely because of the effect of multiple circuits toward reduction of surge voltages.
5. With lightning arresters provided only at the transformer junctions, a 1,175-kv basic impulse insulation level should be satisfactory.
6. The critical points to avoid in substation design are radial taps at the end of which surges tend to reflect and produce appreciably higher voltages.
7. These recommendations were not modified by considering full waves resulting from shielding failure on the transmission line.

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Electropolarizer Aids in Simplifying Chemical Analysis

Chemical analysis of plating solutions now can be analyzed with a great degree of accuracy and speed by means of an electropolarizer and a portable galvanometer, according to the Patwin Instrument Company and the General Electric Company.

The electropolarizer utilizes the polarographic method of analysis, which saves half the time formerly consumed by the chemical method. Most plating solutions, including copper cyanide, zinc cyanide, cadmium, brass, and nickel, can be analyzed with the equipment.

The electropolarizer eliminates the need for maintaining and standardizing several solutions. In practice, the substance to be determined is dissolved in an electrolyte solution. A small glass cell containing the solution is fitted with the polarizing electrode and a reference electrode. As electric potential is applied, very little current flows until a potential which is characteristic of the particular substance is reached. After that point, a polarographic curve results. If the curve showing the relationship between current and voltage is plotted, a "wave" for the substance develops, and further analysis determines its amount and type.

Recording data from a General Electric galvanometer which is being used in conjunction with the Patwin electropolarizer. The solution being analyzed by means of the polarizer is a standard copper cyanide plating solution. Analysis can be done in 15 to 20 minutes and with a high degree of accuracy

Fast Response of Magnetic Amplifiers

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THE BASIC self-saturating, bridge-connected magnetic amplifier is shown in Figure 1. There the voltages appearing in series with the control windings are labelled as e_c, the control voltage, and e_b, the other possible sources of voltage within the control circuit. e_b arises most commonly from two sources; first, from the changes of voltage drop across control circuit resistance resulting from changes in the control current; and secondly, from voltage feedback connection with the output circuit.

A steady-state amplifier output is defined when the integral of e_c over each half cycle is equal and opposite to e_b integrated over each half cycle. That is to say, a steady-state exists when the difference of the average e_c and e_b is zero. Furthermore, the change in volt-seconds area between two successive output voltage pulses is proportional to the integral $\int(e_c-e_b)dt$ taken over the first of these half cycles. Full response to a step input of control voltage can be obtained with a delay of one half cycle of the supply frequency. This may be done by introducing $e_b=e_c$, but delaying this e_b one half cycle after e_c is applied. The half-cycle delay is easily implemented by using a low control-circuit resistance and deriving the negative feedback voltage, e_b, entirely from the load circuit.

Negative feedback decreases gain as is widely recognized. Therefore the foregoing method of achieving half-cycle response sacrifices voltage gain unless the ratio between the number of turns in the control winding and output winding is reduced also. The current gain can be increased by positive current or magnetomotive-force feedback thereby increasing the power gain of the amplifier. Since the control circuit resistance is small this current feedback introduces no appreciable voltage into the control circuit. The response of the amplifier depends upon the control circuit voltages, and therefore the positive current feedback improves power gain without affecting the speed of response. Figure 2 shows the control characteristics of a low-level amplifier adjusted for half-cycle response. The positive feedback windings are connected in parallel with the load through a 13,000-ohm resistor. An inductance is included in series with the control circuit for the purpose of filtering out the a-c components of control current. This has negligible effect on the amplifier time constant because it is not necessary for the average control current to change appreciably.

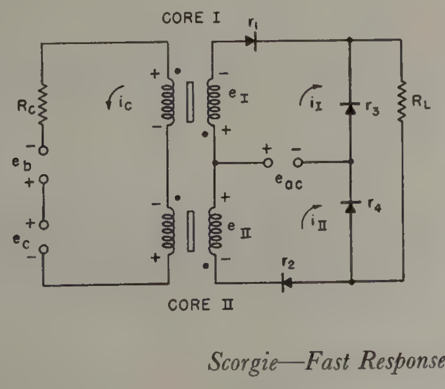

Figure 1. Basic self - saturating bridge - connected magnetic amplifier

The same ideas for obtaining fast response are applicable to those amplifiers controlled by an a-c signal. The feedback voltage pulse, however, must be of alternating polarity and can be derived from a resistor in series with the a-c leg of the output bridge. Unfortunately the a-c-controlled amplifier exhibits a high quiescent output current, particularly when using cores with high remanent flux. The high quiescent current arises from a condition which allows the voltage of the gating core to rise above the a-c supply voltage prior to saturation of that core. The quiescent current can be greatly reduced by paralleling the output windings with resistor-rectifier combinations which fix the gating core voltage at the instantaneous value of the supply voltage.

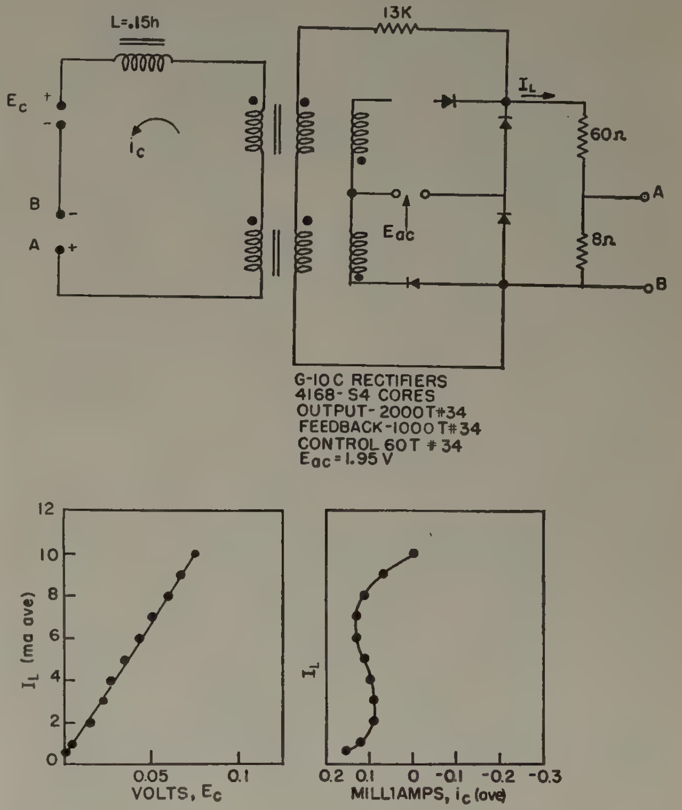

Figure 2. Control characteristics of a low-level amplifier adjusted for half-cycle response

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Digest of paper 53-336, "Fast Response of Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Fault-Resistance Effect on Ground Fault Current

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GROUND FAULT currents may be reduced substantially when fault resistance is included in the fault circuit. The majority of faults that occur on a power system involve ground and occur between conductor and tower. When a fault occurs to a steel tower or grounded wood pole on a grounded system the footing resistance is included automatically in the fault circuit and the resulting ground current may be materially less than that calculated neglecting the fault resistance.

Large grounded power systems with heavy concentrations of generation are subject to system faults near the generating stations that produce extremely high fault currents. These high currents may inflict severe circuit breaker interrupting duties and stress on system equipment. The reduction of ground current is rapid as the fault distance increases from the source; therefore, the most severe faults are those within a few miles of the generating station. The effects of fault resistance on ground currents, however, may be of considerable importance to ground relaying of faults in other sections of the system where fault-current levels are much lower.

The single phase-to-ground fault only is discussed; however, current limitations also result for the double line-to-ground fault. The limitation of ground current by the inclusion of tower footing resistance in the fault circuit is very effective for points in the system where the ratio of system reactance at the point of fault to the fault resistance is low. This is generally true of system locations having high ground fault currents. The ground fault current is equal to $3E_n/X_T$ where $X_T = X_1 + X_2 + X_0$, the sum of positive, negative, and zero sequence system reactance to the point of fault. If tower footing resistance R is included, the formula becomes $3E/(X_1 + X_2 + X_0 + 3R)$ where R and X bear a 90-degree vector relationship. Reference is made to Figure 1 which shows the ground current expressed as a percentage of the current that would result with zero tower footing resistance, plotted as a function of the ratio of system reactance to point of fault for a single phase-to-ground fault to the tower footing resistance. The curve shows marked current reductions when the ratio of the system reactance to fault resistance is low.

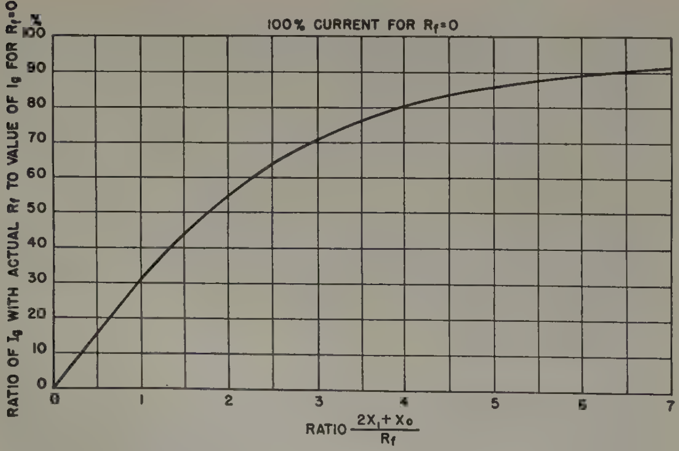

Figure 1. Effect of fault resistance on ground current symmetrical rms values

When the transmission-line towers are tied together with overhead ground wires adjacent to the substation, the effective fault resistance is reduced greatly as the footing resistances are in parallel for all towers connected to the ground wire. In order to secure an effective value of footing resistance in the fault circuit, it is necessary to insulate the ground wire from the towers and from the station ground mat leaving only one tower on each circuit connected to the ground wire to drain off static charge.

The results of limited field tests give reasonable correlation between the meggered values of tower footing resistance and the actual values as indicated by staged fault-current tests.

Footing resistance may be such as to produce a low ratio of X_T/R at most any location in a system. Resulting fault currents are known to be in the order of 50 per cent or less than the expected value normally determined by neglecting fault resistance.

The effect of a particular tower footing resistance on a given fault is determined readily from Figure 1. The reactance X_T for a single line-to-ground fault is determined and the ratio X_T/R where R is the tower footing resistance is calculated. Projecting this ratio upward to the curve and reading the ordinate gives the percentage of fault current that will result compared to the current calculated with zero tower footing resistance.

The inclusion of tower footing resistance in faults on high-voltage systems may result in substantial reduction of ground fault currents. The degree of current reduction is a function of the ratio of $(X_1 + X_2 + X_0)/R_F$. This can be important in any portion of the system as the tower footing resistance may reduce a normally calculated fault current with footing resistance neglected to a current value below the normal ground relay pickup.

The introduction of effective values of resistance in the fault circuit at system points of large generation will result in rapid attenuation of the d-c component of fault current. This will require circuit breakers to open only symmetrical currents further reducing the magnitude of current to be interrupted. Also because of fault phase-angle the recovery voltage is reduced, lessening the severity of breaker duty.

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Telephone System Applications of Recorded Machine Announcements

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The applications of voice-recording equipment discussed in some detail can be divided into four general groups: Announcements made directly to and providing a service to subscribers, such as weather forecasts and the time of day. Announcements to assist subscribers in connection with telephone service, that is, intercept announcements when an individual calls a vacant or disconnected terminal, or emergency announcements if an unusual condition prevents normal service. Announcements to expedite service and assist operators in completing calls, including completion of calls from a dial to a nondial phone, and advising operators of the time delay for completing long distance calls. Specialized announcement or recording services, such as price quotation and ticket reservation.

Although the Bell System is concerned primarily with providing communication services, a number of very useful sidelines have developed one of which is in the voice-reproduction field. With the vast growth of the telephone system and the increasing complexity of its networks of lines and switching systems, numerous instances have arisen wherein the general service could be improved or additional services given to telephone users by employing voice-reproduction devices. Some announcement systems, such as the Weather Forecast Bureau, provide invaluable service to businessmen and holiday pleasure-seekers alike. Other systems, such as the use of a machine to quote the delay time for setting up long distance calls in busy holiday seasons, relieve operators of a tiring task and increase efficiency within the telephone system. The process of providing these added services has led in turn to extensive development effort in the recording field by the Bell Telephone Laboratories and an appreciable investment has been made in announcement devices and the associated control equipment.

TYPES OF ANNOUNCEMENT EQUIPMENT

There are three types of voice-reproduction equipment in common use at the present time.

1. The optical method, utilizing a photographic film record and having an associated scanning system with photoelectric cells.
2. The magnetic method, using a magnetic pattern set up in magnetic media such as wires, tapes, drums, and so forth.
3. The mechanical method in which the recording is engraved or embossed on a recording material.

Careful studies have been made before selecting announcement devices for each application, the optical and magnetic methods having been given the most extensive use in telephone announcement work.

GENERAL FEATURES

Each new announcement system has its individual features and has introduced its own individual problems but, in addition, there are several features common to all.

The transmission considerations on announcement systems are, of course, highly important. Because the speech on announcement systems is one way and the calling subscriber cannot ask the machine to repeat, transmission, as a first requisite, must be loud and highly intelligible but at the same time the distribution system must not impose a level so high as to create cross-talk on other circuits. The objective is to give a grade of transmission at least equivalent to that obtained on an average telephone call, and suitable machines, amplifiers, and networks must be provided with this in mind. Also, when giving an announcement to large numbers of stations simultaneously, provision must be made to prevent conversation between the connected stations. This is accomplished by the use of a low common impedance output or bus to which the calling stations connect through networks providing a sizable transmission loss. A typical example of this is shown in Figure 1 where the loss between two simultaneously connected stations is so great that conversation between the stations is impossible.

There is also the problem, in many systems, of connecting calls through to the announcement at the proper time, and of disconnecting them after an interval. The calling subscriber, in general, is allowed to hear the announcement for a long enough time to permit him to absorb the message but, on the other hand, a cut-off interval must be established to avoid prolonged listening which monopolizes valuable trunk and switching facilities. This problem is solved by a suitable switching circuit usually controlled by signals from the announcement machine.

Due to the importance of machine announcements complete reliability of service is a primary consideration and therefore extensive alarm equipment is provided. Since the announcement machine is the heart of the system, it is the practice to furnish a stand-by machine with automatic

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Essentially full text of paper 53-219 "Telephone System Applications of Recorded Machine Announcements," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in the AIEE *Transactions*, volume 72, 1953.

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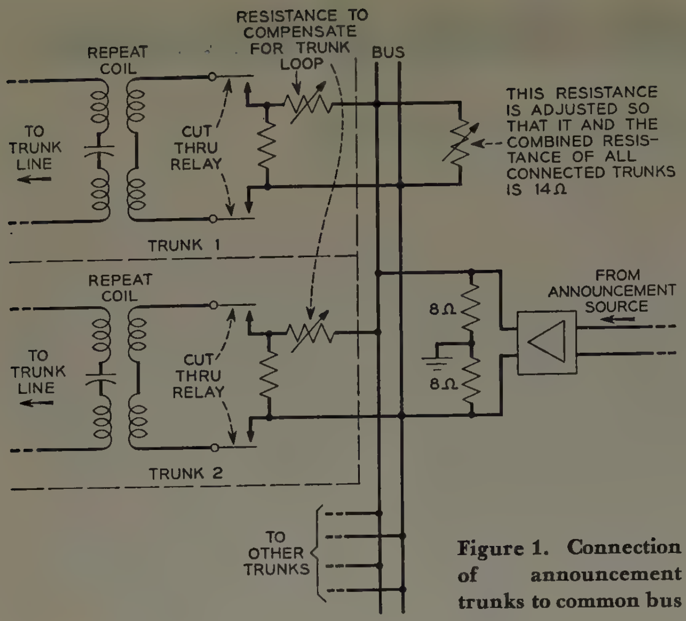
RESISTANCE TO COMPENSATE FOR TRUNK LOOP
REPEAT COIL
BUS
TO TRUNK LINE
CUT THRU RELAY
THIS RESISTANCE IS ADJUSTED SO THAT IT AND THE COMBINED RESISTANCE OF ALL CONNECTED TRUNKS IS 14Ω
TRUNK 1
REPEAT COIL
FROM ANNOUNCEMENT SOURCE
8Ω
8Ω
TO TRUNK LINE
CUT THRU RELAY
TRUNK 2
TO OTHER TRUNKS

Figure 1. Connection of announcement trunks to common bus

transfer arrangements in the event of failure of the machine serving the load. Also, arrangements generally are provided to permit an operator to make announcements if all machines fail.

WEATHER FORECAST SERVICE

THE WEATHER ANNOUNCEMENT system has proved to be a very popular service since the first installation in 1939. In New York City, for example, the service averaged 71,000 calls per day in 1951. This rate varies extensively and has reached a daily high of about 270,000 calls under severe weather conditions.

The forecast information for this announcement system is received through the co-operation of the Government Weather Bureau. The information is transmitted over a direct teletype line to the recording room in a telephone central office. A typical recording room is shown in Figure 2 with the teletype machine and recording turret. In addition to providing a convenient service to telephone subscribers, this system relieves the Weather Bureau personnel of considerable telephone answering effort. It is customary to change the announcement at hourly intervals, or more frequently, if necessary, to take care of sudden weather changes.

This service presently uses magnetic-type announcing machines developed for the purpose.[1] The machines and amplifiers function on 110 volts alternating current and therefore an inverter is provided for use if a power failure occurs. The inverter operates from a 48-volt battery in the telephone central office and produces 110 volts alternating current.

The general arrangement of the announcement system is shown in Figure 3. The trunks from various central offices are ordinarily terminated on the output bus at the main bureau but, if the area served is sufficiently large, subcenters are provided with two cable pairs between the main bureau and the subcenter.

As shown in Figure 3, the output of the announcement machines is connected to the bus through "pattern" relays which are designed to operate in a sequence giving each machine an equal amount of use in the "load" and "stand-by" positions. This pattern is controlled automatically and the proper machines are selected when an "erase" key in the turret is operated, preparatory to a new recording. While one machine is kept in service, the remaining two available machines are recorded simultaneously, but cannot be put in service until the operator has monitored both. While the operator monitors the verbal accuracy of the report, a speech monitor circuit checks the volume level and prevents the operator from connecting a machine to the load if specified limits are not met. The operator places the two newly recorded machines in their proper places as the load and stand-by machines by the operation of a single key. A speech monitor circuit is connected across the bus as a check of the presence of speech and its volume level. If the volume is too low or there is no speech, a transfer to the stand-by machine occurs. As an additional safeguard, such as the remote eventuality of all machines being out of service, the operator will give the announcement herself by plugging her microphone into a manual announcement jack causing the operation of a pair of manual relays and the manual service relay. A machine recording may be made during manual announcement by way of contacts *A* shown in Figure 3.

As stated in the foregoing, subcenters may be provided, with two cable pairs to the main bureau. Each pair has an amplifier at the subcenter and the outputs of the two amplifiers are tied together through a bridge circuit, one arm of which is the subcenter bus. If either channel from the main bureau fails, the other can carry the load at the subcenter with a very slight drop in volume. Normally operated relays are connected across the cable pairs which will release and cause an immediate alarm if an open line should occur. A relay arranged to operate on speech is connected across the output of each amplifier under control of interrupters and if the relays fail to operate on each interrupter cycle, an alarm is sounded. The bridge connection between the two channels prevents the output of one working channel from operating the speech alarm relay of the other channel, if it is out of order.

The announcement given for Weather is approximately 25 seconds in length and therefore incoming calls are connected through immediately, at any part of the announcement. However, a distributing and timing circuit is provided to control supervision signals in the incoming trunk circuits. After several announcements, the incoming trunk is arranged to send a disconnect signal toward the originating central office equipment.

TIME ANNOUNCEMENT

CORRECT TIME has become a very important item to most of us. Early in telephone history, subscribers acquired the habit of calling the operator for the correct time. This became burdensome to the operator, particularly in the larger areas, and for this reason a number of these areas were arranged with a centralized time-of-day bureau that could be reached by dialing a listed number. In this system, one operator at the central point announced the time at 15-second intervals. This repeated announcenent was tedious and operators tired after a short time. Due to the repetitive nature of time announcements it ppeared that the use of a machine announcement system would contribute materially to the convenience and efficiency of the operating personnel and accordingly it was made available. The service is extensively used. In New York City, the average daily calling rate for 1951 was 68,000. During the annual baseball World Series, the time bureau also carries the inning-by-inning score and in 1951, 1,456,000 calls reached the bureau during the 6 days of the series.

The machine shown in Figure 4, built by the Audichron Company of Atlanta, Ga., is furnished presently for time service. The unit shown is equipped with two machines arranged for automatic transfer in the event of failure. However, a single machine also has been made available for use in towns with a small amount of time-of-day traffic.

The machine, which uses the optical method of voice reproduction, is arranged to give a statement such as "At the tone, the time will be one twenty-two and ten seconds" followed by a short spurt of tone. The announcements are given at 10-second intervals. The machines are driven by 60-cycle commercial power when it is considered to be regulated closely enough. In other installations a local power source with closely controlled frequency can be provided. As in the Weather Bureau, inverters operating from the 48-volt battery supply 110 volts alternating current if a power failure occurs.

The distributing network and subcenter arrangement is similar to that for the Weather Bureau, see Figure 3. The general arrangement of a 2-channel time-bureau installation is schematically illustrated in Figure 5. Here one announcing machine serves the load with the other acting as a stand-by.

Figure 2. Weather forecast service recording room

If both announcement devices should fail, a visual and audible alarm is given and a key is operated to transfer the load to a manual announcement source which employs a third amplifier, not associated with the machines. These announcements may be made from either a microphone and emergency key and lamp box or from a regular switchboard position as indicated in Figure 5. The operator, of course, obtains the time from a clock and the tone spurt is not given.

Inasmuch as a time announcement is short, incoming calls are connected through between announcements only. With machine operation, a short closure of ground on lead *RV*, from contact *A* on the machine, preceding each announcement, serves to connect waiting subscribers to the bus. During emergency switchboard operation, an incoming call on a trunk grounds lead *CW* operating relay (*CW*) and lighting the "calls waiting" lamp in the switchboard. The operator answers the call by plugging a cord in the associated jack which starts a relay interrupter. This causes the momentary closure of contacts (*RV*) to

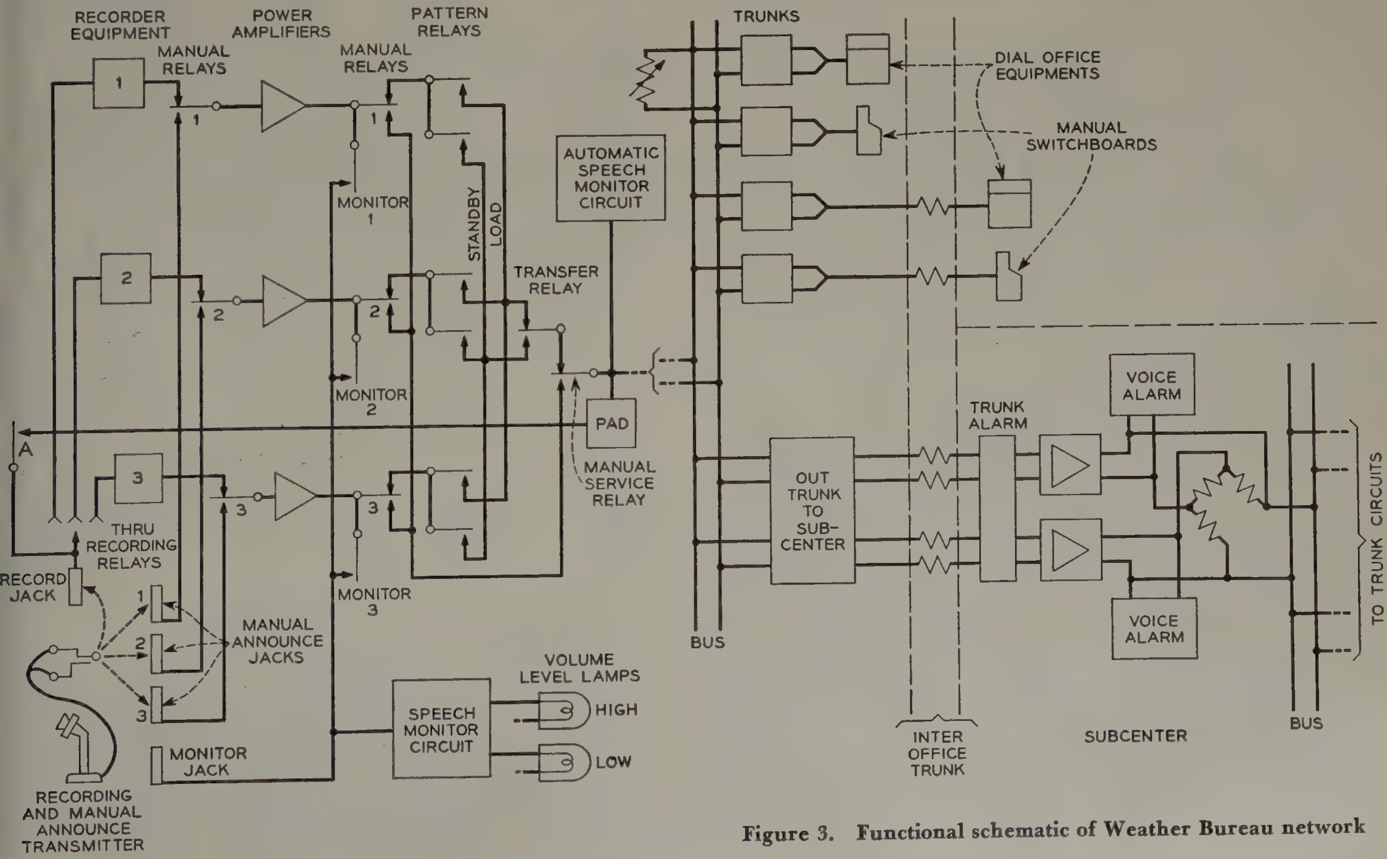

Figure 3. Functional schematic of Weather Bureau network

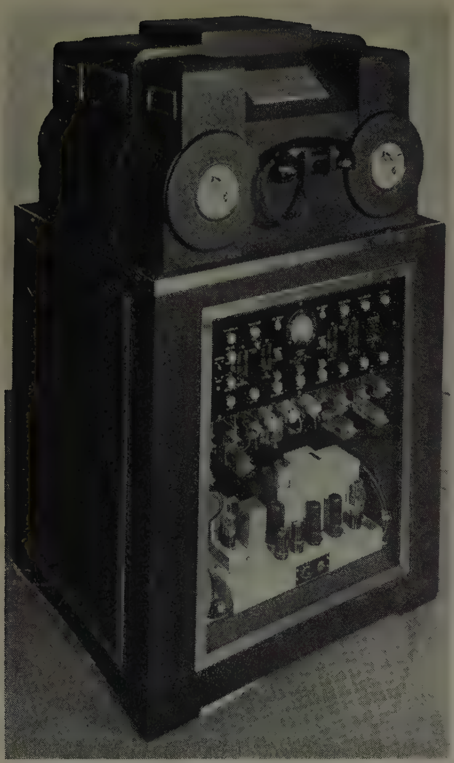

Figure 4. Typical time announcement machine

connect through the waiting trunks, and then closes contact (*AN*) which extinguishes the cord supervisory lamp, serving as an indication to the operator to announce the time. A calling subscriber is allowed to listen to several announcements, after which disconnect supervision is sent back to the originating equipment.

Various alarms are provided at the main bureau. These include voice alarms, fuse alarms, faulty distributing relay operation, and a current interruption alarm which operates if there is a momentary failure of the 110-volt a-c power, to indicate that the time may be slightly incorrect.

RECORDED INTERCEPT ANNOUNCEMENTS

THIS SERVICE IS one of the newer users of recorded announcements and will reduce the amount of operator effort in this respect by about 50 per cent.

Calls in the telephone system which usually are intercepted by an operator are those that reach vacant or disconnected terminals, changed number terminals, or lines in trouble. The calls to vacant or disconnected terminals can be handled by a machine announcement which advises the calling subscriber that the number he reached has been disconnected and requests him to make sure that he is calling the right number. Calls to changed numbers or to lines in trouble cannot be answered by such a simple statement and are therefore still routed to an operator who gives definite information regarding the status of the called line.

It has been the practice in large areas to concentrate the intercepting traffic from a number of offices to a single switchboard or desk. Figure 6 is a functional schematic of the arrangements usually furnished at a central intercepting point and the trunk equipment at both ends of one trunk from an outlying office to the central point. At the outlying office the calls to be intercepted are directed to the intercepting trunk by the switching equipment which also sends signals ahead to indicate the type of answer to be given at the central point. Calls to vacant or disconnected terminals will reach the announcement machine, calls to lines in trouble will reach an operator's jack and lamp for this service while calls to changed-number terminals will reach another jack and lamp. Referring to Figure 6, a call to a changed number will cause relay (*TRO*) of the outgoing trunk to operate and connect battery and ground toward the incoming trunk, but the polarity is such that relay (*P*) will not operate and the call is routed to the operator's "Regular" answering jack and lamp. A call to a line in trouble will operate both relays (*TRO*) and (*RV*), reversing the polarity and causing polarized relay (*P*) to operate and direct the call to the operator's "Trouble" lamp and jack. Calls to either vacant or disconnected terminals cause the momentary operation of relay (*M*) of the outgoing trunk, applying a 115-volt battery to both sides of the line which operates the simplex connected relay (*SX*) at the incoming end. The operation of relay (*SX*) sends the call to the announcement machine.

The announcement machines are so constructed that contact *CT* closes during the period between announcements to operate the (*CT*) relays of the trunks. The pulses from contact *CT* also cause the operation of a counting circuit and, after a predetermined number of announcements, the call is transferred to the operator's "Regular" jack and lamp on the assumption that the calling party

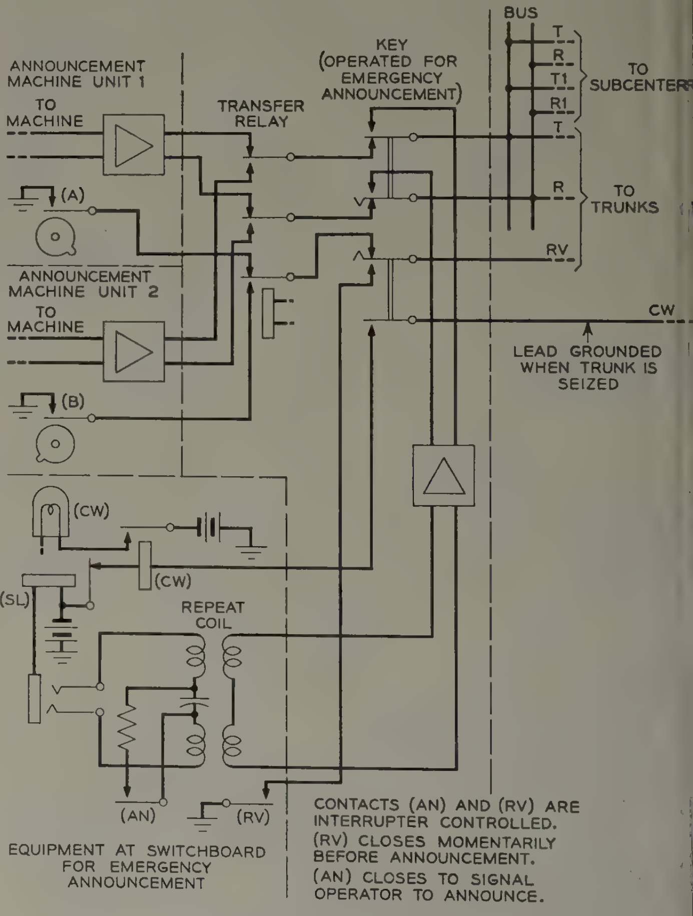
ANNOUNCEMENT MACHINE UNIT 1
TO MACHINE
(A)
ANNOUNCEMENT MACHINE UNIT 2
TO MACHINE
(B)
(CW)
(CW)
(SL)
REPEAT COIL
(AN)
(RV)
EQUIPMENT AT SWITCHBOARD FOR EMERGENCY ANNOUNCEMENT
TRANSFER RELAY
KEY (OPERATED FOR EMERGENCY ANNOUNCEMENT)
BUS
T
R
T1
R1
T
R
RV
TO SUBCENTER
TO TRUNKS
CW
LEAD GROUNDED WHEN TRUNK IS SEIZED
CONTACTS (AN) AND (RV) ARE INTERRUPTER CONTROLLED.
(RV) CLOSES MOMENTARILY BEFORE ANNOUNCEMENT.
(AN) CLOSES TO SIGNAL OPERATOR TO ANNOUNCE.

Figure 5. Functional schematic of time-of-day bureau

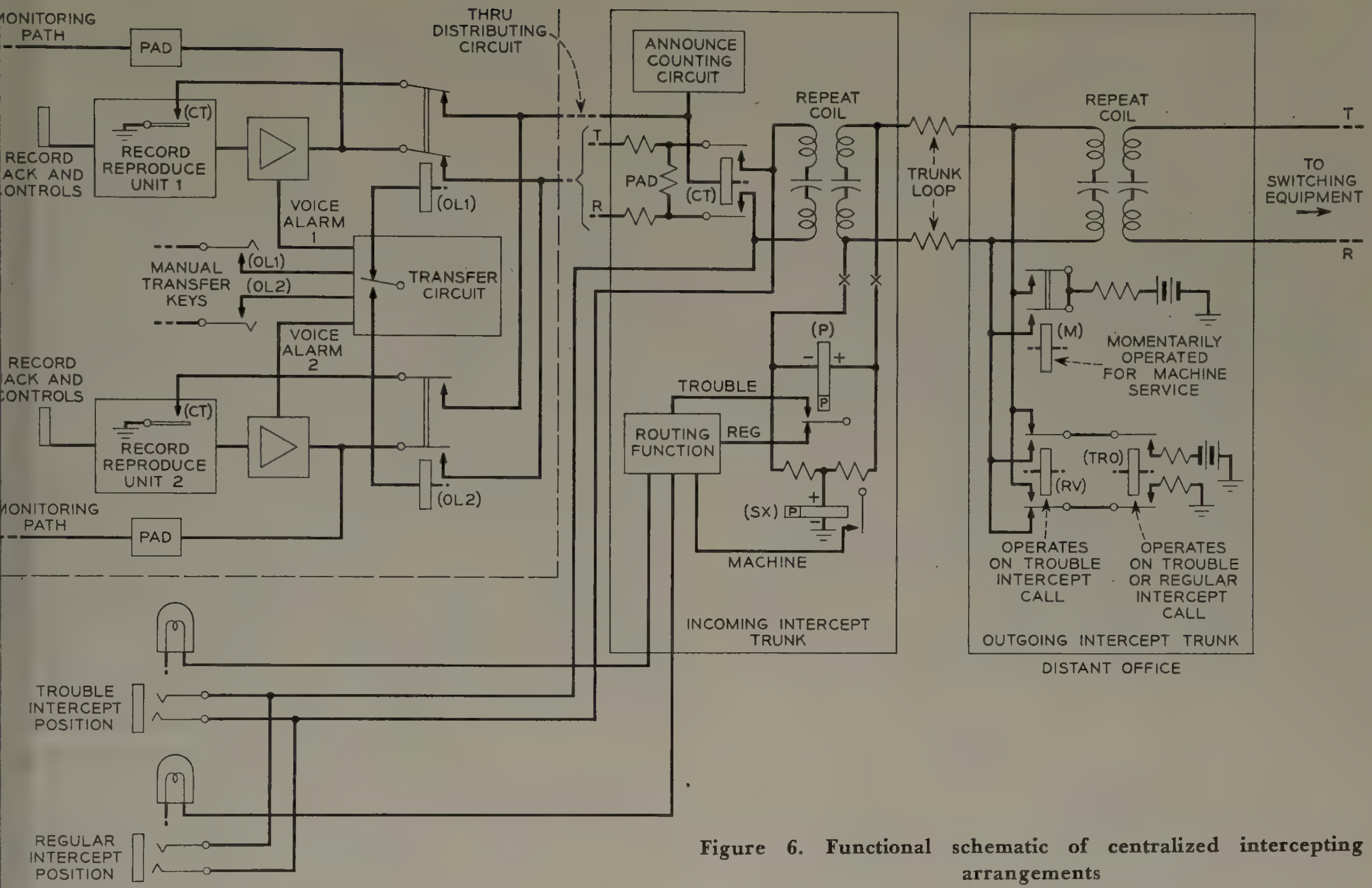

Figure 6. Functional schematic of centralized intercepting arrangements

requires some information in addition to the machine announcement.

The machines used for intercepting service are the magnetic type and are furnished in duplicate with automatic transfer. In addition to advising the calling subscriber that he reached a disconnected number, he is told that he is listening to a recorded announcement. This latter statement is necessary since observations have shown that without it, about 40 per cent of the calling subscribers attempt to converse with the machine, believing it to be an operator.

EMERGENCY ANNOUNCEMENT SYSTEM

ON RARE OCCASIONS, magnetic-type announcement machines have been used to advise telephone subscribers if an emergency, such as an air raid alert, causes the temporary discontinuance of operator service. The method of applying this announcement is interesting due to its simplicity.

In a manual (nondial) central office the announcement is applied by superimposing it on the battery feed to the line relays.

In any dial central office some operator services are required, and therefore trunk circuits are furnished from the dial equipment to these operators. Since subscribers are accustomed to receiving audible ringing signals between the end of dialing and the answer of the called party, the trunk circuits have provision for applying audible ringing signals toward the calling party through a low-capacity capacitor (usually 0.02 to 0.04 microfarad) until such time as the call is answered. Under an emergency condition the recorded announcement is applied by simply disconnecting the ringing from a group of trunks and transferring the common leads to the announcement bus.

CALL ANNOUNCER

THE INTRODUCTION OF dial telephone systems could not be accomplished in all central offices at the same time. This situation called for some arrangement for completing calls from dial to manual telephones and, accordingly, an arrangement known as the "call indicator" was originally provided at the manual office. This system was such that the dialed number would appear before the manual operator as lighted numerals. With further expansion of the telephone system and the introduction of large tandem centers using common control equipment, the call announcer was developed for use at these tandem centers. This machinery allowed an appreciable reduction of equipment and modification at the manual office.

If a call is made from a dial area to a line in a manual office, the number dialed is recorded by relay operations. When the operator in the distant manual office is ready to serve the call, the operated relays cause the machine to announce the digits of the number, in proper sequence, to the distant operator.

The call announcer machine itself is of the optical type and can announce the digits *0* to *9* and party line letters *W*, *R*, *J*, and *M*. Two machines are ordinarily in use, each carrying half the load, but in the event of a speech failure on one of the machines, an automatic transfer connects all the load to one machine.

DELAY QUOTATIONS FOR TOLL CALLS

Another newcomer to the machine-announcement field is the "Delay Quotation" system. This was developed to relieve operators of the repetitious chore of quoting toll-line delay times during periods of heavy traffic such as Mother's Day, Christmas, and so forth.

The general arrangement for handling these quotations on delayed toll calls is shown in Figure 7. Referring to this figure, assume that an operator at point *A* dials a call for point *C* via a toll crossbar office at point *B*, and that the switching circuits, testing, find that all trunks from *B* to *C* are busy. If the delay is to be of such length that the usual supervisory signals will not inform the originating operator adequately of the availability of trunks to point *C*, it becomes desirable to quote a period of time before the call can be completed, to prevent the originating operator from making repeated unsuccessful attempts. Initially, when delay intervals became 1/2 hour or more, the delay quotation was handled by patching (at the Supervisory Panel) the overflow control circuit to a jack appearing before an operator who gave the quotation, but since the development of the machine system, the operators no longer are required to do this. After the patch to the delay quote jack has been set up, the calls will be directed to overflow trunks and the originating operator hears the quotation. She then turns the call over to her own delayed-call operator for later completion.

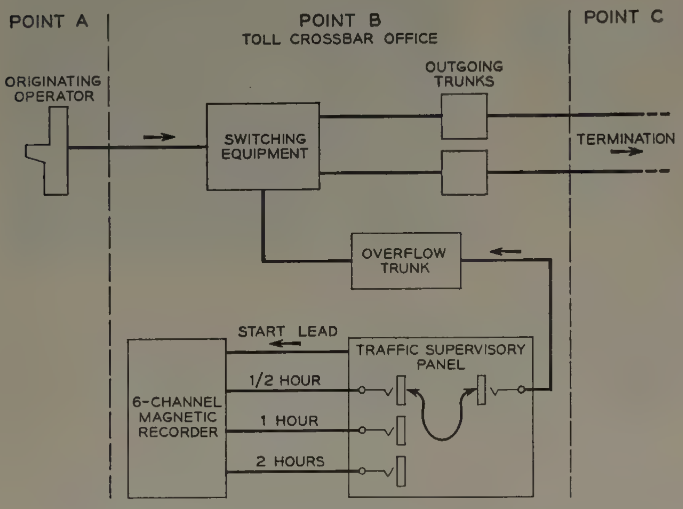

Figure 7. Diagram of delay quote system

The jacks at the supervisory panel that carry the delay quotations are connected to magnetic-type recorders. These machines have six recording channels, each of which can be used for a different delay time. A group of trunks may be patched to any desired delay announcement. Contacts on the machine are provided to give supervisory flashing signals toward an outward operator, before the announcement occurs, to attract her attention in case she has left the connection.

No stand-by machines are furnished on these installations but, if a voice failure should occur, an alarm is given and the operator can quote the delays.

SPECIALIZED APPLICATIONS

Voice recording and announcement machines have been put in service for a number of uses as a convenience or important business aid in furnishing particular services. One of the earliest applications of magnetic-type recorders for an announcement system was made in New Jersey in 1937 to give potato growers up-to-the-minute information regarding prices, car movements, loadings, and holdings. To receive this information it was necessary to call a listed number and, since the installation was in a manual central office area, the operator completed the call via a jack to the announcement bus. The system employed two machines, one in service and the other being held as a spare or for new recordings.

A management announcement system, used on a few trial installations, permits the management of large corporations to disseminate important information to certain groups of employees without these employees leaving their regular work locations. The information is recorded on a magnetic-type machine and interested employees call a number in the company *PBX* to hear this announcement. Since it often is necessary to make a new recording without interrupting service, two machines are provided. These machines also can be operated sequentially if a particularly long announcement is needed.

Arrangements have recently been provided at the New York Stock Exchange to give price quotations on some of the most active stocks. The brokers are able to obtain the latest price by dialing the number listed for the particular stock. The quotations on the announcement machines are kept up-to-date constantly by recordings from attendants at the trading posts on the floor.

Magnetic-type recorders also were used in a large New York newspaper office in 1937, not as an announcement system, but as recording devices. In this instance, reporters out on assignments, could go to the nearest telephone, call their office, and be connected to a recorder on which they would record their reports for later transcription.

There have been other special applications of voice-recording equipment including the railroad reservation information.[2]

FUTURE DEVELOPMENT

As far back as the late 1920's it was found that recorded announcements would serve to expedite service as applied to the Call Announcer. This experience indicated that voice recording was a valuable tool in communications. As seen from the foregoing descriptions a number of other applications have been made with resulting advantages in convenience and services rendered to both subscribers and operating personnel.

At the present stage, various other applications are being explored, more are anticipated within the next few years, and indications are that this field should become increasingly important in the years ahead.

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Magnetic Amplifiers' Influence on Hysteresis Loops

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FELLOW AIEE

THE SCOPE of this article is limited to a qualitative description of the steady-state operating characteristics of those high-performance amplifier circuits which are classed as single-phase "self-saturated" types. Only resistive loads are considered.

Nearly all of the analyses of magnetic amplifiers published so far fail to relate the magnetic amplifier control characteristics to a truly rectangular hysteresis loop. Those analyses which do consider the hysteresis loop usually show that a self-saturated magnetic amplifier would have an infinite gain or "trigger" action between full output and minimum output. Since very rectangular loop-core materials do not show such extreme trigger action, it appears that an important factor is being neglected in such analyses. The author believes this neglected factor involves the proper consideration of the eddy-current effects which cause the operating dynamic hysteresis loops to be wider than the static loop.

Figure 1*A* shows idealized static and dynamic major and operating minor loops for a doubler circuit with high-impedance control circuit. Figures 1*B* and 1*C* show gate winding voltage and current waveforms respectively, for minimum output and for "firing" angles of 120 degrees and 0 degrees (full output). The shaded areas emphasize the 120-degree "firing" angle conditions. Like numbers on the hysteresis loops and voltage and current waveforms indicate corresponding operating portions of the three curves. The notch in the operating minor loop between points 6′ and *B*′ and the prefiring gate current from 6′ to 0 are predicted by eddy-current considerations. Figure 2 shows the predicted notch appearing in an oscillogram of the operating minor loop recorded during validity checks using Deltamax cores in the doubler circuit.

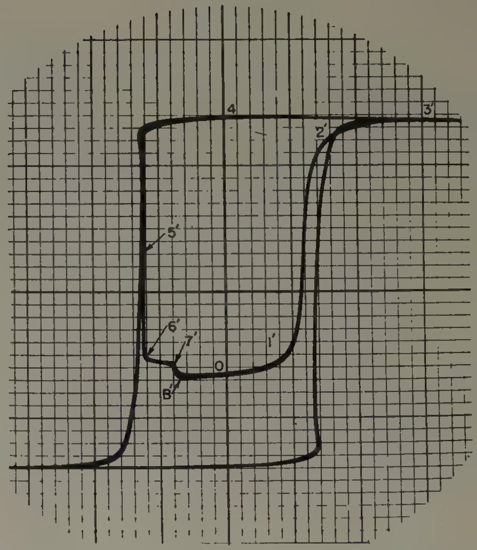

Figure 2. Major and operating minor hysteresis loops for high impedance control circuit doubler

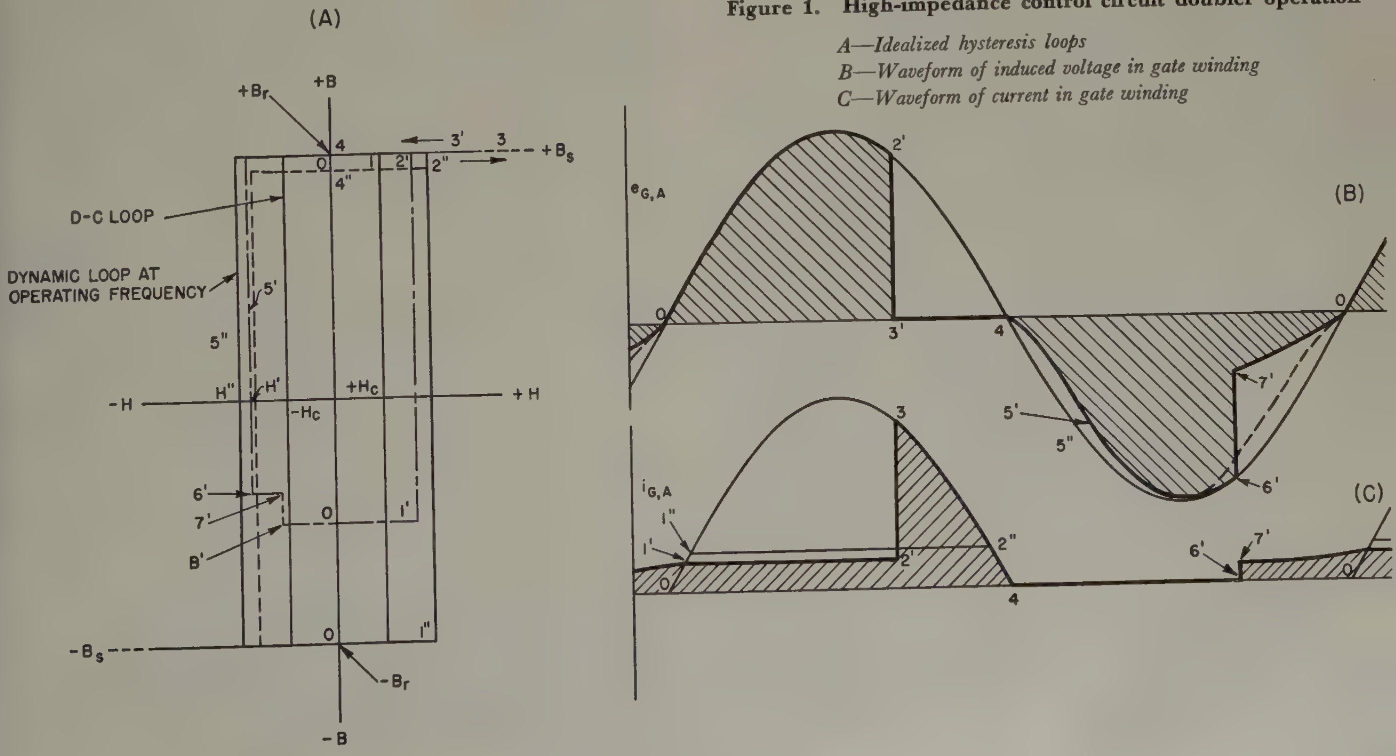

Figure 1. High-impedance control circuit doubler operation

A—Idealized hysteresis loops
B—Waveform of induced voltage in gate winding
C—Waveform of current in gate winding

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Historical Approach to Speed and Tie-Line Control

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THE PROBLEM of matching the generation to the load is basic with the electrical industry. Since the very earliest days of a-c systems, the maintenance of a frequency equal to the nominal figure at which the system operates has provided the simplest indication of this balance. Until the late 1920's very little consideration was given to anything more than approximate accuracy of frequency, with the result that deviations from normal of as much as 1/2 cycle were not at all uncommon. Integrated time was of no consequence.

The advent of synchronous electric clocks in important numbers provided one incentive to greater accuracy, both in the short-time (instantaneous) and the long-time (integrated) matching of the generation and the load. The maintenance of electric time has gone through a cycle beginning with complete disregard, moving up through a stage of overemphasis, and then settling back about where it belongs as a by-product of reasonably good quality which can be attained without undue effort.

Automatic equipment designed to maintain a flat 60 cycles first made its appearance a little before 1930 on a very simplified basis. It was successful in its primary purpose but it had a serious secondary drawback, in that extremely heavy load swings were inflicted upon the plant saddled with the regulating burden. This method also showed its disadvantages with respect to maintaining tie schedules on interconnections. Since there was no way of knowing on which side of the tie the load change (which had caused the frequency change) had originated, a controller sensitive to frequency only, by the law of averages would correct half the time for errors which originated elsewhere, thus further upsetting the tie-line schedule.

Telemetering to bring tie-line indication to a central point where it could be combined with frequency indication proved the ultimate means of developing a satisfactory automatic control system which would do not only all that an alert operator could do, having complete instrumentation at hand, but furthermore could make the adjustments on a quantitative basis. Starting on the assumption that it is desirable for load swings to be compensated for by changes of generation in the same area (as opposed to the do-nothing approach which forces them to be shared by all the neighbors), controllers are available today which will accomplish this desired result. The method goes by the name of tie-line bias control and it can be demonstrated to be correct in theory as well as by the experience gained with many installations. Contrary to earlier thought on the subject, no master station whose only function is to supply a standard 60 cycles is required or even desirable. The method was developed for use on two systems connected by a single tie line. It is, however, readily expandable to include any complex type of interconnection. All that is required is the isolation of a load regulating area by means of meters suitably placed at the boundaries so that it is possible to show on a single totalizer the net of all the ties to adjacent areas. A load regulating area is a physical entity and need bear no relation to corporate ownership lines except as such may be appropriate or convenient.

While most of the original installations were made on hydroelectric plants, due primarily to simplicity, such a situation could not long continue because hydroelectric plants of suitable characteristics and locations were available only in limited numbers. Today steam stations carry the bulk of the regulating burden and they must continue to do so.

Within the plants themselves there have been many improvements in the application of the control, to the end that fluctuations on individual units now can be controlled definitely, both as to rate of output change and allowable maneuvering range. Furthermore, it is possible to insure that any change at all is distributed correctly, having in mind the efficiencies of all the individual units on the control at any instant, and the way those efficiencies vary with loading.

At the present time there are three avenues open for further work, all of them worthy of attention. The first involves the role and capabilities of individual prime mover governors. On any system only a fraction of the units are under the direct control of the automatic machinery and the rest still respond to their governors, which over the years have been very much improved. The second involves a refinement of the control systems to provide still smoother operation. Developments along this line have showed steady progress over the years. Necessarily, with more functions to perform the equipment has grown more complex. The stage just about has been reached where a plant can operate under automatic control more smoothly even than under manual direction. Work along these lines still is going forward. The last is that of education. In any system various groups of engineers often working in different departments are involved one way or another in this subject and too few of them have a complete understanding of the problems which the others face. For just one example, the operating men would like to be able to use the best and most modern units on a system for speed and tie-line control purposes, while the plant men responsible for efficiencies, for a very natural reason, feel that fluctuating loads operate to their disadvantage. The continued co-operation of electrical, mechanical, and operating groups is essential for the best solution of a never-ending problem.

Digest of paper 53-34, "Historical Approach to Speed and Tie-Line Control," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Raydist Systems for Radiolocation and Tracking

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Several radio systems have been developed for locating a ship's position on the earth's surface and for tracking it. The measurement of phase, as is done in the Raydist systems, offers accuracies which exceed those of other methods.

THE LARGE NUMBER of systems for radiolocation and tracking that have come into use offer the prospective user a wide choice to meet a particular need. Two of the most important characteristics to be considered in a choice are the inherent accuracy with which the system can measure distance and the bandwidth required in the radio spectrum.

An analysis of the accuracy of various pulse and continuous-wave systems leads to a number of questions that are receiving currently a great deal of attention, particularly with regard to the velocity of propagation of radio waves under actual conditions. Aside from propagation phenomena, there are several basic considerations pertaining to the ultimate accuracy of various systems. Pierce[1] has summarized some of these basic limitations on accuracy. For example, a pulse is required to be about 50 cycles or more of the carrier frequency in duration in order to obtain reasonable efficiency of radiation. This pulse length may have to be increased considerably to comply with restrictions in the bandwidth assigned for the service. Pierce estimates that the measurement of time interval between received pulses can be made to about one-fifth of the pulse length, or equivalent to a distance accuracy about 10 wavelengths in space for a 50-cycle pulse. Some hope is offered, particularly at high frequencies, of improving the accuracy to perhaps 1 wavelength if the two pulses are carefully matched in shape before radiation and superimposed with equal amplitudes at the receiver.

The analysis is summarized in Figure 1, which is adapted from Pierce's[1] Figure 5. An extension is made thereon of the measurement of phase to the range of frequencies used in Raydist. It is seen from the figure that measurement of phase, as is done in Raydist systems, offers accuracies considerably exceeding those of other methods. The instrumental accuracy of Raydist systems can be made high enough then to shift the emphasis on precision from instrumental problems to those dealing with the propagation of radio waves under practical field conditions. This article describes the heterodyne method of making phase-comparison measurements in various types of Raydist systems and the applications in which they have filled needs not met by other systems.

THREE TYPES OF RAYDIST SYSTEMS IN COMMON USE

Raydist Type E System. This system was developed for precise 2- or 3-dimensional tracking of a small continuous-wave transmitter for purposes of navigation, surveying, or position plotting. The system gives instantaneous hyperbolic position data of a mobile transmitter with reference to two or more fixed receiving stations. The receiver is part of a relay station that retransmits the received phase information to a common point designated as the master station where the phase comparison is made and position data recorded.

Phase measurements are facilitated by the use of a second fixed transmitter known as the reference transmitter transmitting on a frequency separated from the mobile transmitter by a small difference frequency in the audio range such as 400 cycles. The heterodyne process serves to transfer the radio-frequency phase angles to audio-frequency phase angles of the same value so that the actual measurement can be made at audio frequencies. This audio heterodyne frequency containing the phase information appears at each fixed relay station. It is then easily transmitted either by wire or as modulation on a radio link to the com-

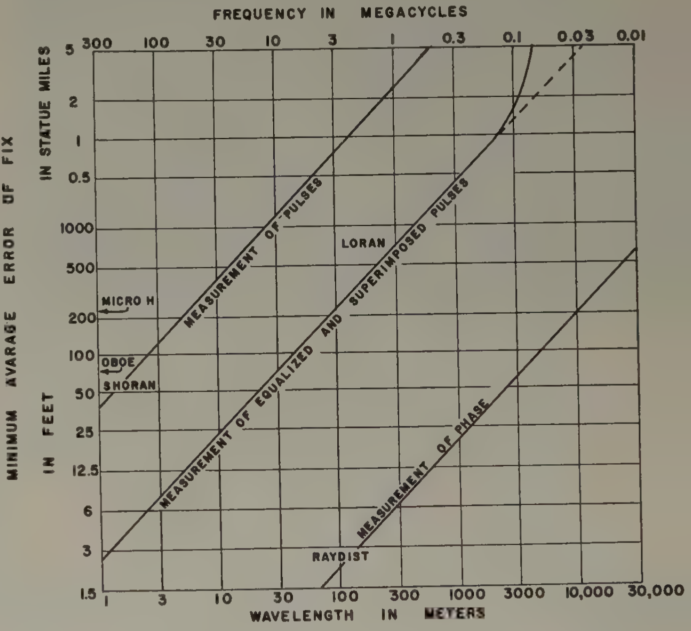

Figure 1. The estimated error of a fix by various methods of radiolocation

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Full text of special article recommended for publication by the AIEE Joint Subcommittee on Electronic Instruments.

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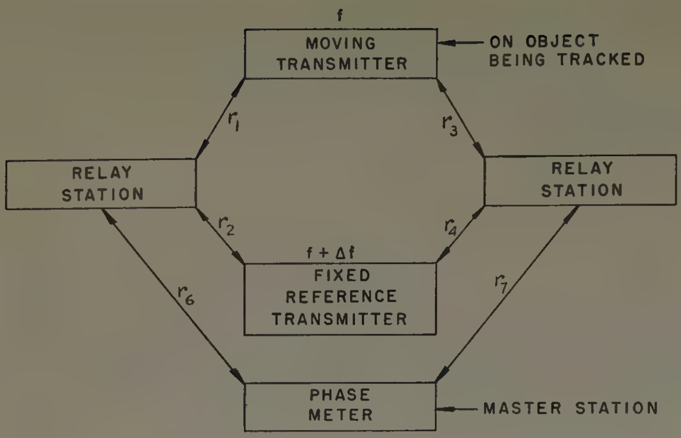

Figure 2. Raydist Type E system block diagram

$$\psi=\frac{2\pi f}{c}(r_1-r_3)+\frac{2\pi(f+\Delta f)}{c}(r_4-r_2)+\frac{2\pi(\Delta f)}{c}(r_7-r_6)$$

where ψ *=phasemeter reading. In basic system, since* r_2, r_4, r_6, *and* r_7 *are fixed distances, the general equation above reduces to*

$$\psi=\frac{2\pi f}{c}(r_1-r_3)+k$$

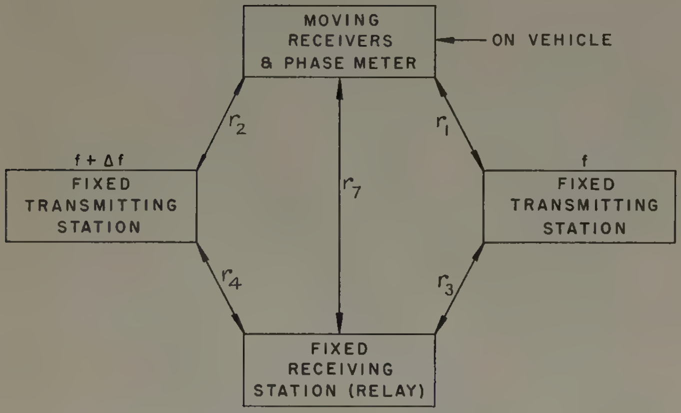
MOVING RECEIVERS & PHASE METER
ON VEHICLE
r2
r1
r7
f + Δf
FIXED TRANSMITTING STATION
f
FIXED TRANSMITTING STATION
r4
r3
FIXED RECEIVING STATION (RELAY)

Figure 3. Raydist Type N system block diagram

$$\psi=\frac{2\pi f}{c}(r_1-r_3)+\frac{2\pi(f+\Delta f)}{c}(r_4-r_2)+\frac{2\pi(\Delta f)}{c}(r_7)$$

where ψ *=phasemeter reading.* r_3 *and* r_4 *are fixed distances and the general equation reduces to*

$$\psi=\frac{2\pi f}{c}(r_1-r_2)+\frac{2\pi(\Delta f)}{c}(r_7-r_2)+k$$

mon master station for phase comparison. Figure 2 is a block diagram of the Type *E* Raydist system with which is noted the formula relating position and phase angle.

Raydist Type N System. The Type *N* system was developed as a general 2-dimensional navigation arrangement requiring only two narrow-band frequency assignments in the middle-frequency or low-frequency bands. This system is unsaturable, that is, any number of Raydist-equipped ships or vehicles can obtain position-fixing data simultaneously and continuously.

This system was derived from an earlier arrangement of a Type *E* system "turned inside out," wherein the fixed receiving stations of the Type *E* system become fixed transmitters, and the transmitting stations, mobile and reference, become receivers. The heterodyne principle still is used, by separating the fixed transmitters in frequency by a small difference. The position is obtained by comparison of the phases of the heterodyne signals as received directly at the mobile vehicle with the phase angles received at the fixed receiving station and retransmitted or relayed as audio signals to the mobile vehicle. The system is hyperbolic in that the line-of-position pattern is a family of hyperbolas established between pairs of fixed transmitting stations, which are at the foci of the hyperbolic grid. The block diagram of this Type *N* system is shown in Figure 3, with the mathematical explanation along with an equation relating position to phase angles. It will be noted that in this case, the second term in the equation representing the phase shift on the relayed signal is not a constant. This can be applied as a minor correction for most accurate data, but usually can be neglected except at the very low primary frequencies. Figure 4 illustrates a Type *N* system and shows the configuration of the various parts of the system.

Raydist Type RE System. The Type *RE* Raydist system was developed for the direct measurement of distance between any two points. Again, it uses the phase-comparison technique and retains the audio-frequency heterodyne principles common to the basic Raydist method. The *RE* system is based on the principle of phase comparison between two signals received at two locations, each signal being transmitted from the opposite location. Reference to the basic block diagram Figure 5 and the mathematical relationships will show that the reading of the phase indicator will vary directly with the distance between the two stations. Hence, this system is a "pure range," or range-only system.

In the *RE* system the two stations are designated master and relay, since the received phase information at the remote station is relayed to the master station for comparison with the signal received directly at the master station.

It is significant to point out that the two primary frequencies used are not exactly harmonically related, and there is no synchronization required between them. This is brought about by separating the two frequencies by a simple ratio plus a small difference frequency. This

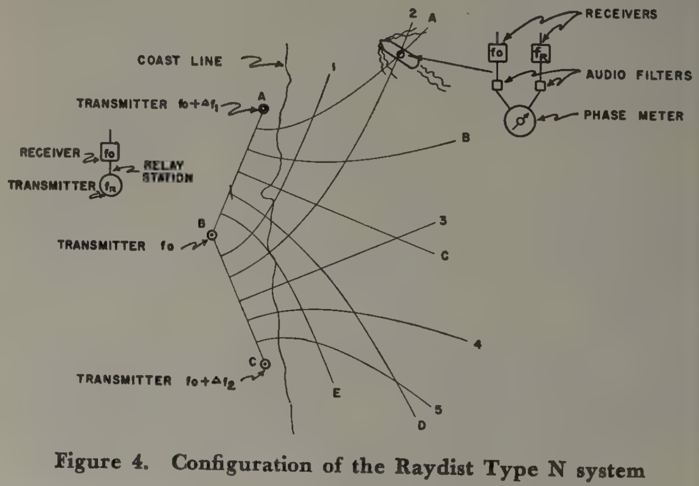

Figure 4. Configuration of the Raydist Type N system

difference frequency appears as an audio-frequency heterodyne in the master-station receiver of frequency Δf. This relation between the two fundamental frequencies is expressed by

$$f_2 = nf_1 + \Delta f$$

where

n = any integer or simple ratio of two integers
Δf = audio frequency (usually 400 cycles per second)

As can be seen from Figure 5, the heterodyne appearing in the relay receiver has the frequency $\Delta f/n$ and must be multiplied by n after relaying to the master station and before phase comparison can be made. In practice $n=2$ is used, although higher values can be used. Theoretically, $n=1$ is permissible, although there are many practical difficulties in simultaneously transmitting and receiving continuous waves of nearly the same frequency from the same location. Experimentally, this has been done, but only at limited ranges.

Derivations of equations relating distance to phase angle are found in articles by Hastings[2] and Comstock and Hastings.[3]

RAYDIST INSTRUMENTATION

ALL THREE of the Raydist systems just described measure phase angles in the same way at the master station. In the heterodyne method, all data signals exist as audio frequencies which readily can be amplified, filtered, split into quadrature components, and applied to the windings of 2-phase electromechanical resolvers. These synchro resolvers give a shaft position output which represents in mechanical degrees the phase difference in electrical degrees. Attached to the resolver shaft are mechanical counters which add or subtract each revolution of the synchro with each 360-degree change of phase to the "whole" count. For recording purposes, a small potentiometer is attached to the resolver shaft and a standard direct voltage is impressed across the potentiometer. Thus a direct voltage that varies linearly with the resolver position is available for operating recording devices such as strip-chart recorders or plotting boards.

The phasemeter readings in a Raydist system are relative in that a comparison is being made between the signals received at one point (for example, on the moving object being tracked in the Type *N* system) and the signals received at another point (usually a fixed point such as a relay station). In the Raydist equations (Type *N* system) it can be seen that the phase information at the relay station appears as constant terms. Similarly, in a Type *E* system the phase of the mobile object being tracked is compared to the phase of the signals from the fixed reference transmitter, the latter appearing as constants in the equations. In the *RE* system the phase angles vary at both ends of the system, but it is only their difference that varies directly with distance, all other terms being constants. These constants are eliminated in the phasemeter by setting the phasemeters to the proper reading at some point in the system. Thereafter the reading of the phasemeters is correct throughout the entire system.

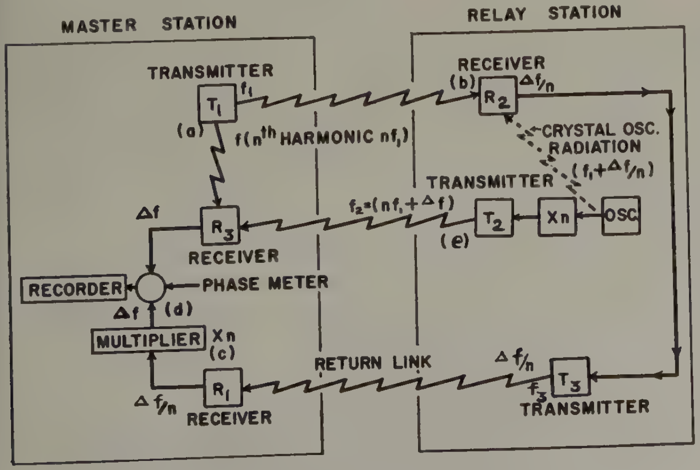

Figure 5. Block diagram of the Raydist Type RE system

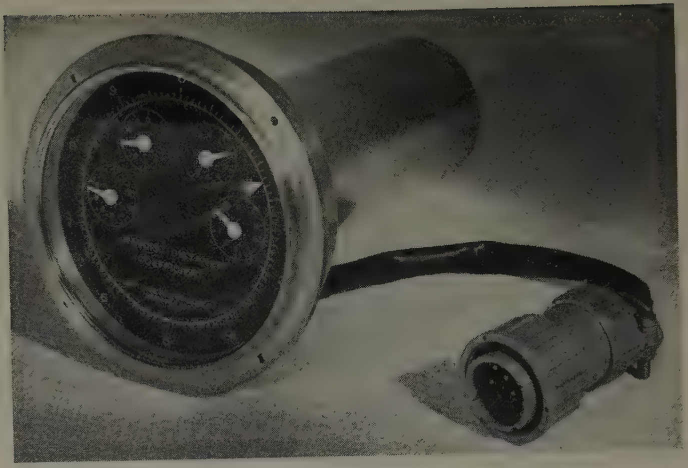

Figure 6. The electromechanical phasemeter

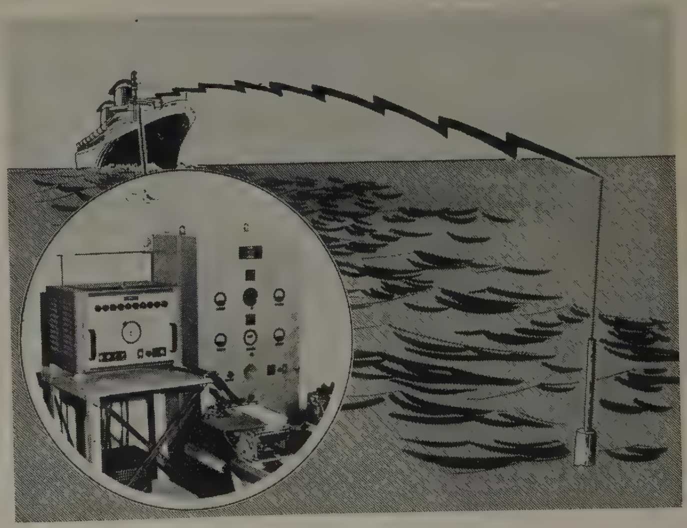

Figure 7. The Raydist Type RE system used for the "United States" speed trials in which a small buoy containing the Raydist equipment is placed in the water and an indicator and recorder are installed on the ship. Measurements of distance and speed can be made with an accuracy of 1 part in 5,000

This type of phasemeter, in addition to being relatively simple, affords considerable discrimination to noise since due to its own inertia, it is in effect a low-pass filter. Of course, very high speed tracking may call for other methods of measuring and recording rapidly changing phase angles. These methods require more elaborate and costly instrumentation especially when high discrimination against noise is necessary. Most of the tracking and navigation problems to which Raydist systems have been applied to date have used the synchro-type phasemeter with negligible dynamic errors. The type of electromechanical phasemeter just described is illustrated in Figure 6.

In any continuous-wave phase-comparison system such as Raydist, there arises the problem of "lane identification." A lane can be defined as the distance along the baseline (in a hyperbolic system) that the object being tracked must move in order to produce 360 degrees of rotation of the phasemeter. In Raydist this is usually equal to the distance represented by the half-wavelength of the primary frequency being used.

The phasemeter will read accurately any fraction of a lane, but it has no way of identifying which particular lane it is reading. This situation can be resolved by starting out with the proper "lane count" at some point in the system and adding or subtracting lanes each time the phasemeter completes 360 degrees of rotation.

If the phase readings are recorded on a strip-chart recorder, loss of count due to intermittent loss of signal or noise bursts can be readily faired through and the proper count re-established. This is generally true in practice and is recommended in such applications as surveying and slow-speed tracking work.

In general navigation work it is most desirable that a method be provided to obtain an initial fix anywhere in the system without previous knowledge of position. To do this requires a method of lane identification. One method that has been used successfully but requires additional frequencies provides multifrequency transmissions from the transmitters in a particular system. These transmissions may be either simultaneous or sequentially operated and in effect set up multiple "fine lane" systems from a common baseline. The differential readings of any two phasemeters, each being connected to its own system, yield a "coarse lane" measurement. The width of each coarse lane will be equal to a half-wavelength at the difference frequency between the two primary frequencies. By a proper choice of frequencies in such a system, it is possible to resolve the "fine lane" ambiguity by readings on the "coarse lane." Of course for complete resolution of ambiguity it may be necessary for the operator to determine which coarse lane he is occupying, but in many applications this is either unnecessary or is readily determined from other information.

A second method of lane identification makes use of secondary baselines of shorter length adjacent to the primary baselines. These shorter baselines produce less fine lanes for a given coverage area than do the long baselines. The accuracy of a particular fix varies directly with the baseline length in electrical degrees or wavelengths. Therefore shortening the baselines sacrifices accuracy and reduces the number of ambiguities. For a particular area to be covered, ratios between long and short baselines and the number of such steps necessary can be found that will allow the accuracy of each successive step to be sufficient to resolve the position within one lane of the next step. This process will allow a final determination of position with the accuracy available in the basic system.

RECENT APPLICATIONS OF RAYDIST SYSTEMS

In the last several years Raydist systems have come into use in a variety of different applications. The basic Type *E* system has been used as a surveying tool in the Bahama Islands. Distances between several of the islands were measured so as to provide sufficient data for an examination of the accuracy of closure in a net. Some of the lines in that net also duplicated lines previously measured by Shoran, thereby providing a comparison of distances as measured by the two very different methods. The closure was considered excellent in the net of Raydist lines, with a probable error of about 6 meters. The lines ranged from 41 to 146 kilometers. The agreement between a single Raydist measurement and an adjusted average of several Shoran measurements was about 3 meters in a line 86 kilometers long, which is considered excellent agreement.

The Type *E* configuration also has been used for 3-dimensional tracking to obtain valuable research data. The object being tracked carries a small expendable continuous-wave transmitter and the data are automatically recorded on the ground for later analysis and study. Recently an evaluation was made of a Raydist 3-dimensional system tracking an airplane at 16,000 feet altitude. Askania theodolites were used as a check on the accuracy. The results in general showed the Raydist measurements to agree with the theodolites to within about 30 feet in altitude, which was within the experimental accuracy of the theodolites.

Type *E* equipment has been used also by the Portuguese Government for hydrographic surveying off the east coast of Mozambique. It is also in routine use by the United States Army Corps of Engineers[4] for hydrographic survey and dredging operations. In these operations the master station is installed aboard the survey boat or dredge along with the mobile transmitter being tracked and the position data are available instantly. The survey boat or dredge is supplied with hyperbolic overlays on navigational charts of the area being worked.

The Raydist Type *N* system has come into use in geophysical survey work in the Gulf of Mexico during the past year. In this work horizontal control of geophysical survey boats operating well beyond line of sight of the shore is necessary. It also is necessary in this application that the system or "chain" be available to any and all parties requesting the location service. The frequencies presently being used for this service lie in the recently allocated band from 1,750 to 1,800 kc for Industrial Radiolocation Service. Ranges up to about 100 miles from the coast are being obtained regularly using transmitters on the shore of less than 0.5 kw, the maximum permitted in this service. The need for the Raydist system in geophysical offshore operations is shown by the demand that has been made by the geophysical operators for the Raydist equipment during the short time it has been in operation. The efficiency and reliability of Raydist in this field is being proved daily by nine geophysical parties who are using it. As of March 1953, two Raydist chains are in operation in the Louisiana-Texas Gulf Coast areas, and a third is under construction.

The Raydist Type *RE* system has become an accepted means for measuring the speed of ships. The superliner *SS United States* used the system for speed standardization on its early sea trials in May 1952. This was done under near-hurricane conditions that would have caused very costly delays had Raydist not been available.[3,5] That was the first official use of the system for speed trials; subsequently, it has been used on ship-speed measurements for several other large commercial ships.

In this application the relay station equipment is installed in a free-floating buoy, and the master station is located aboard the ship being tested. Figure 7 is an illustration of the system as used by the *United States*. The ship steams either toward or away from the buoy on any straight-line course. The system indicates and records distance traveled relative to the buoy, and, with suitable time measurements, gives directly the speed through the water.

Raydist has many advantages over the time-honored "measured-mile" course which in the past has been the only means of accurately "standardizing" a ship. The "measured mile" had to be on shore and therefore did not give true water-speed. A further advantage is that the trial can be conducted miles at sea where there is adequate free area and depth of water. Before the actual *United States* trials, preliminary tests on smaller ships showed that Raydist could measure ship's speed through the water to an accuracy of 0.01 knot during steady speed runs of considerably less than 1 mile.[3]

CONCLUSION

PHASE-MEASURING methods of radiolocation and navigation have been shown to fulfill some important needs that are not met by pulse systems. Several particular arrangements of Raydist have been described for different applications of phase-measuring methods, all of which make use of the heterodyne signal between continuous-wave transmitters and thereby obviate the need for phase-locking transmitters or extreme accuracy of frequency control.

The Raydist systems lend themselves readily to instrumental accuracy of a high degree for the medium ranges considered herein, the accuracy in practical cases with propagation beyond line of sight compares very favorably with the best results obtained with pulse systems that are restricted to line of sight. Applications of Raydist have proved economical and convenient for use in accurate geodetic and geophysical surveys. They also have provided new standards in the measurement of speed in ship trials.

It may be expected that the use of continuous-wave systems employing phase-measuring techniques will continue to develop rapidly in the next few years. They are inherently narrow-band systems that require comparatively small portions of the radio spectrum. The rapid development of continuous-wave systems well may duplicate the extraordinary progress that was made during World War II in the applications of pulse methods to navigation problems.

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Miniature Intercommunication System for Aircraft

A miniature intercommunication system small enough to be held in a pilot's hand has been designed by North American Aviation for Navy *T-28B* trainers.

The midget unit provides for communication between cockpits, for receiving any of six separate communication and navigation signals, for handling a command signal, and for transmitting.

In the 2-place *T-28B* trainer, a control panel in each cockpit supplies instructor and student with a selection of six incoming signals from the aircraft's various radio equipment. The intercommunication control panels also can be used as an air-borne classroom device for training pilots in communications procedure.

Adaptable to military aircraft other than the *T-28B* and to commercial airplanes, the miniature set has design features insuring against failure during operation. A common reason for interrupted communication in conventional systems is failure of the dynamotor. North American has developed the new set to eliminate the dynamotor and draw power from a 28-volt d-c source.

Using miniature electronic parts to save cockpit space, the unit is $3^{3}/_{4}$ inches high by $5^{3}/_{4}$ inches wide and $7^{3}/_{8}$ inches deep, and weighs about 4 pounds. Each control panel is located so that a pilot in full flying gear can manipulate interphone controls with either hand. Latest techniques of electronic design have been used in the system's amplifiers and other integral units. Electronic packages can be plugged in or removed from a control panel without disturbing wiring or internal components, helping to keep maintenance and repair costs low.

The system's control panel meets military requirements for intercommunication sets. It can take prolonged exposure to salt spray, and temperatures ranging from -67 degrees Fahrenheit to $+185$ degrees Fahrenheit, as well as rough vibration and sudden shock as high as 30 times the force of gravity.

Up to 18 received signals can be accommodated by each control panel with additional mixing switches.

Stability of DBPC Inhibited Oil

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WHILE 2,6-di-tertiary-butyl-para-cresol (DBPC) has been established as a suitable oxidation inhibitor for transformer oil, its use in oil for reclosers has not been evaluated. A number of persons have raised the questions of the effect of DBPC on rate of settling, particle size, and quantity of carbon formed by an arc, and the effect of an arc on the inhibitor itself. In the present investigation, the operation and stability of DBPC inhibited oil was studied to determine if the inhibited oil showed any undesirable characteristics which would make it unsuitable for use in oil circuit reclosers.

Eight 15-kv distribution-type oil circuit reclosers were used in this study. These reclosers have plain break contacts with a pair of fiber-lined plates arranged to aid deionization. The reclosers operated on a timing sequence of two instantaneous operations followed by two retarded operations, followed by lockout. Four reclosers of 10-ampere coil rating and four reclosers of 50-ampere coil rating were used. Two reclosers of each coil rating were filled with uninhibited oil and the other two of each coil rating with oil containing 0.30 per cent by weight DBPC. The reclosers then were operated at 7.2 kv, 30-per-cent power factor, 150 amperes for the 10-ampere reclosers, and 705 amperes for the 50-ampere reclosers. The 10-ampere reclosers performed a total of 220 interruptions, and the 50-ampere reclosers performed a total of 40 interruptions. These conditions of applied voltage, current, power factor, and number of interruptions were chosen to simulate conditions which can be considered greater than average duty before maintenance is required on distribution-type reclosers.

Oil stability was evaluated by testing the oil samples after 100 and 220 interruptions of the 10-ampere reclosers, and after 20 and 40 interruptions of the 50-ampere reclosers. The oil tests included: (1) total acid number, (2) interfacial tension, (3) viscosity, (4) dielectric strength, (5) steam emulsion number, (6) DBPC content, (7) carbon content, (8) carbon settling.

The total acid number of both oil samples showed only minor changes, which are not considered to be important in oil circuit recloser operations. The inhibited oil showed a higher initial acid number, which was apparently due to the inhibitor itself. Study of this point confirmed the suggestion that DBPC is slightly acid when dissolved in transformer oil. This acidity, however, is very slight and has no measurable effect on the recloser operation.

The values for interfacial tension of the oil samples showed steady and comparable decreases. At a maximum, the final value was only 20 per cent lower than the original value; a decrease of 60 per cent generally is required before oil will sludge.

Both the oils showed similar decreases in viscosity and dielectric strength. No significant difference in the stability of the oils was found. After filtration of the oils, there was no change in the steam emulsion numbers, which indicates that no metallic soaps were formed.

The DBPC content of the inhibited oil showed a very slight increase. The effect of an arc on oil is to break down the oil hydrocarbons to gases such as methane, ethane, acetylene, and hydrogen, and to form carbon and insoluble hydrocarbon polymers. As oil is consumed in the process, the percentage of inhibitor should increase slightly. It is apparent that DBPC is not destroyed in an arc.

The carbon content of the oils, which is measured by filtration and washing of a measured volume of oil, was shown to be somewhat greater in uninhibited oil than in inhibited oil at an equal number of interruptions. This was notable particularly in the 50-ampere recloser. Variations in the total arc energy are considered to account for these results.

Photographs taken of the oil samples after interruption showed no apparent difference in the size and shape of the carbon particles formed in the two oils. The carbon in the inhibited oil of the 50-ampere reclosers seemed to settle more slowly than the carbon in the uninhibited oil. This phenomenon has been observed by others. It was found that addition of enough water to saturate the oil will change the rate of carbon settling. Under this condition, carbon in both inhibited and uninhibited oil settles at the same rate. Because a recloser oil in service contains water, the practical significance is that there is no difference in the rate of carbon settling in either oil.

It is concluded from the available evidence that there is no essential difference in the stability under arcing of oil inhibited with 2,6-di-tertiary-butyl-para-cresol (DBPC) and uninhibited transformer oil. Further testing on the effects of an arc on partially oxidized oil and aged inhibited oil is in progress.

As a result of this study, it becomes evident that the use of DBPC inhibited oil in reclosers will have no adverse effect on the performance of the apparatus. Therefore, users of such equipment need not keep different oils for transformers and for reclosers. The oxidation resistance of the inhibited oil will provide additional benefits to reclosers just as to transformers. Perhaps the most important benefit obtained in reclosers is the prevention of insulation degradation. The peroxide oxidation products of oil will attack cellulose in insulation. In DBPC inhibited oil, the oxidation products are neutralized before they can react. As a result, the effective life of the equipment is prolonged with DBPC inhibited oil.

Digest of paper 53-56, "Stability of DBPC Inhibited Oil in Oil Circuit Recloser Operation," recommended by the AIEE Committees on Switchgear and Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

Kazumi Oura, deceased, was with Line Material Company, Milwaukee, Wis., and **R. N. Hazelwood** and **R. M. Frey** are with Line Material Company, Milwaukee, Wis.

A Critical Soil Moisture Condition Affecting Buried Transmission Cables

W. A. HADLEY R. EISENSTADT

Experimentation in an idealized soil showed a critical moisture content of approximately 4 per cent by weight separated two distinctly different phenomena whereby heat is dissipated from buried heat sources. Above this moisture content relatively large quantities of heat per lineal foot are dissipated apparently by a circulation phenomenon. Below this content the soil rapidly dries out, materially decreasing the quantity of heat that can be dissipated. The latter may explain the so-called "runaway condition" observed with buried transmission cables.

DURING the course of an investigation on moisture movement in soils around refrigerated pipes,[1] certain phenomena were observed at the hot end of the apparatus which appear to be of interest to engineers dealing with buried transmission cables. The apparatus consists essentially of an insulated pipe, heated at one end, cooled at the other, and packed with small glass beads perfectly spherical in shape. Two sizes of glass beads were used in order to check the influence of capillary spaces of different size. The larger beads were approximately 0.01 inch in diameter producing a material resembling beach sand. The smaller beads (0.001 inch in diameter) when packed in the pipe resembled silt.

Before loading the beads into the pipe a measured quantity of water was added to, and thoroughly mixed with, the beads. The water contained a trace of salt of Cobalt 60 (a radioactive substance). This technique permitted continuous observation of all movements of water in the liquid state by means of a Geiger tube and counter located externally to the pipe. It also permitted a differentiation to be made between vapor movement and liquid movement by the following principle.

All movements of water in the liquid state carry the radioactive salt with them and result in an increase in radioactivity (as registered by the Geiger counter) of one portion of the pipe and a corresponding decrease in radioactivity of another portion of the pipe. At the conclusion of the test, when samples of the moist "soil media" are weighed, dried, and reweighed, if all moisture migrations have occurred in the liquid state the final pattern of radioactivity corresponds to a plot of the per cent wetness. On the other hand, vapor movements carry no salt with them and hence changes in moisture content of one portion of the pipe with respect to another are not accompanied by proportional changes in radioactivity. Therefore, at the conclusion of a run, when the samples have been dried and reweighed, all changes in per cent wetness that are not accompanied by a proportional change in radioactivity indicate the moisture movement was in the vapor phase. When both vapor and liquid movements occur, a combination of the two extremes would result.

DISCUSSION OF RESULTS

BEFORE GOING FURTHER it should be emphasized that the figures shown here are only a few typical examples of the many measured during the course of this investigation.

Evidence of a vapor movement is seen in Figure 1 at the hot end. In this run there was virtually no change in radioactivity, but the final moisture content exhibited a considerable change. This indicates an appreciable migration of moisture in the vapor state away from the heat source at the end of the pipe. In preparation for what is to follow, it should be noted also that this phenomenon occurred at a low moisture content of 1.5 per cent. (This is per cent water by weight of the dry weight of the soil media.) A movement occurring entirely in the liquid state can be seen at the cold end in Figure 5 where both the final radioactivity and final moisture content are proportional. The significance of this phenomenon is discussed elsewhere.[1]

Contrast the foregoing conditions with the results shown in Figure 2. In this case (which occurred at a high moisture content of 9.4 per cent) there was a considerable change in radioactivity during the course of the test. On the other hand, there was very little change in moisture content. At first glance there appear to be two possible explanations for these results. In both cases it is necessary to the explanation that there be a steady migration of liquid to the hot end carrying the radioactive salt with it, whereupon the liquid evaporates and leaves as a vapor, thus depositing the radioactive salt. This action produces a condition of increasing radioactivity at the hot end. Superficially it would appear that the vapor either could (1) migrate to the slightly cooler region of the pipe where it would condense and migrate back to the hot face carrying more salt, or (2) the vapor could leave the apparatus altogether. Considerable care was exercised, and considerable experimental data were amassed effectively to eliminate this second possibility. The appendix is devoted to an explanation of these experimental proceedings which lead to the conclusion that it is

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Complete text of paper 53-228, "A Critical Soil Moisture Condition Affecting Buried Transmission Cables," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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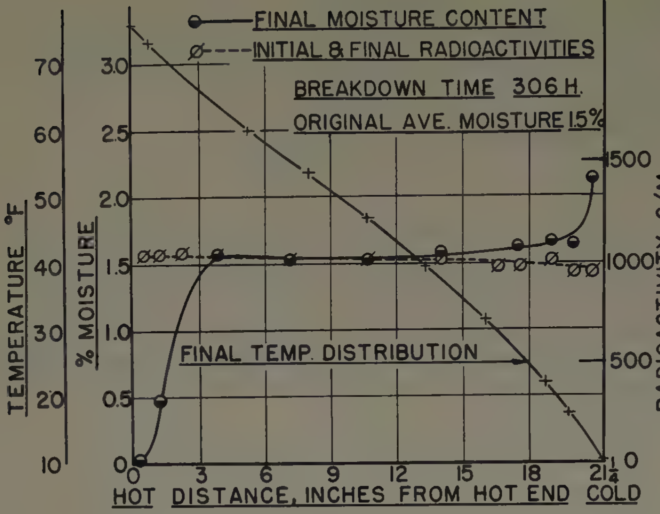

Figure 1. Run number 36: Temperature, moisture, and radioactivity versus distance, 0.01-inch bead

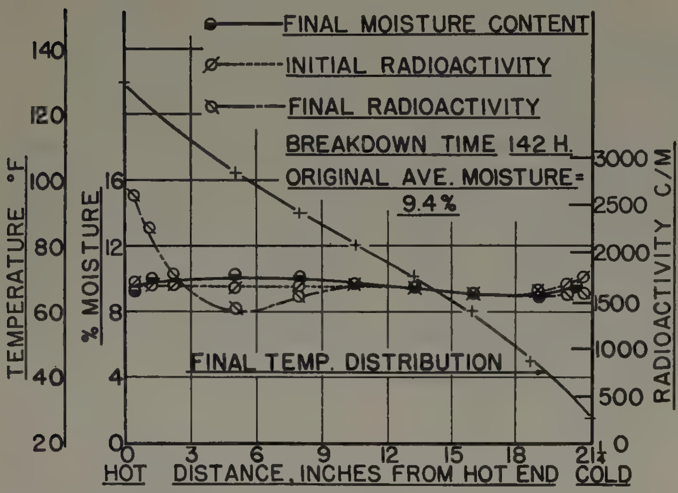

Figure 2. Run number 32: Temperature, moisture, and radioactivity versus distance, 0.01-inch bead

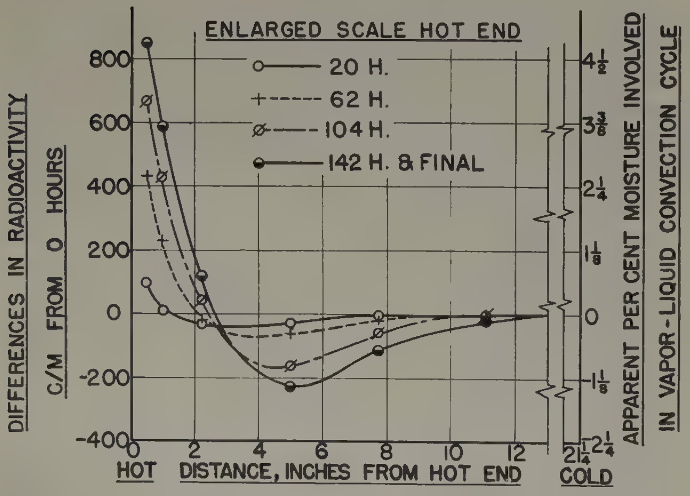

Figure 3. Data from run number 32: Differences in radioactivity from the initial state and apparent moisture involved in convection versus distance, 0.01-inch bead

safe to assume that no appreciable amount of vapor leaves the apparatus.

Furthermore, it will be noted in Figure 2 (and in Figures 3, 4, 5, 6, and in all the data at relatively high moisture content) that there is a decrease in radioactivity in the zone adjacent to the region of increasing radioactivity which is not accompanied by a proportional decrease in final moisture content. This would indicate that the increase in radioactivity at the hot end occurs at the expense of the radioactivity in the zone adjacent, but not at the expense of its moisture content. This alone tends to substantiate the first explanation and its circulatory character.

The gradual nature of the rise and depletion of these two zones during the course of time is shown in Figure 3. Remembering that there is very little change in moisture content, it is almost certain that this steady shift in radioactivity is caused by water evaporating at the hot surface thus depositing its radioactive salt in the hot region. The water leaves this region as a vapor and condenses in an adjacent region which is a few degrees cooler, whereupon it mixes with water containing radioactive salt and moves back to the hot region as a liquid carrying with it more salt. This last movement probably is actuated by capillary forces because the previous evaporation has dried out the hot region slightly and the liquid water moves back in to maintain equilibrium in a manner analogous to liquid moving up the wick of a lamp.

As might be expected the extent of this phenomenon is proportional to the difference in temperature between ambient conditions and the hot surface. In Figure 4 the temperature of the hot surface is much lower and radioactive rise is less pronounced indicating a decrease in the liquid-vapor circulation. If crude numerical values are assigned to this proportionality, it is found that a radioactive rise of the order of 15 per cent occurs when the hot surface is 10 degrees Fahrenheit above the normal ambient temperature and of the order of 50 per cent for a 50-degree-Fahrenheit temperature difference for approximately the same amount of time.

A circulation phenomenon of the type just described is capable of transferring an appreciable amount of heat. The amount of heat that can be transferred by this mechanism alone has been conservatively calculated to be of the order of 4 Btu per square hour-foot. The heat that can be transferred by pure conduction at this moisture content is 16 Btu per square hour-foot so that it would appear that in the range tested the circulation phenomenon increases the heat transferred by at least 25 per cent. The phrase "at least" is used because these calculations are based on a hot source of 136 degrees Fahrenheit and temperatures above that, but below boiling, might give an even greater effect. Furthermore, it should be borne in mind that this circulation phenomenon gives the effect of an increased thermal conductivity of the media immediately adjacent to the hot source, while in a buried transmission cable the geometry of the heat flow paths is radial which gives the effect of increasing the thermal conductivity as distance from the cable increases.[2] Therefore, an increase in thermal conductivity adjacent to the cable is an increase in conductivity at the point of controlling thermal conductivity which materially increases the effectiveness of this phenomenon.

The full significance of the phenomenon is illustrated in Figures 5 and 6. At this time it should be remembered that when the soil medium is relatively dry (as in Figure 1 at 1.5 per cent) no circulation occurred but instead the soil dried out by a pure vapor movement. The circulation phenomenon at the hot end was observed in runs involving soil media containing approximately 4 per cent moisture or more. This shift in operation occurred at about the same moisture content with both sizes of soil particles. Therefore, a critical condition appears to exist at about 4 per cent moisture content. Figures 5 and 6 show a run made at this critical condition and as such are highly revealing. Note that in Figure 5 the final radioactivity plot at the hot end resembles runs made at well over 4 per cent moisture while the final moisture content duplicates the drier runs. In order to determine what occurred it is necessary to study Figure 6 where progressive plots of radioactivity with time at the hot end are shown with a greatly magnified scale. In Figure 6 it will be seen that the characteristic radioactive rise (which is associated with moisture circulation) occurred up until 91 hours, but from then on there was no change in radioactivity through the end of the run at 258 hours. Apparently at 91 hours the soil medium passed from above the critical moisture content to below and (judging from the final plot of moisture in Figure 5) from 91 to 258 hours it dried out by a vapor migration to the cold end. This is important because the thermal conductivity of the soil with circulation is 20 Btu per square hour-foot while the thermal conductivity of the soil as found at the end of the test is only 10 Btu per square hour-foot. This phenomenon gives a logical explanation of the so-called "Runaway Condition" in a buried transmission cable. A cable could be operating in a stable and satisfactory state with regard to dissipation of heat, in a soil just above this critical condition. However, with a very slight drying of the soil causing it to pass through the critical, the moisture no longer circulates but migrates away from the cable, decreasing the heat dissipating ability of the soil by approximately a factor of two. Under these conditions the operating temperature of the cables probably would rise fairly rapidly immediately after the soil passed through the critical moisture content.

An explanation of the critical conditions is: At moisture contents above the critical condition there is enough liquid present so that the liquid in the various interstices of the soil is in contact one with another and forms a connecting liquid grid throughout the soil. Furthermore, as liquid exists in the passages connecting the soil interstices it effectively stops the flow of vapor. Below the critical condition there is not enough liquid in the connecting passages to form an interconnected liquid grid so that liquid flow is prevented but free flow of vapor is allowed.

RELATIONSHIP TO REAL SOILS

It should be emphasized at this time that all of the foregoing experimental work has been conducted on an idealized soil media. It is almost certain that similar results will be obtained for sandy soils and silts, but it would be unwise to extrapolate any numerical results for use on real soils at this time. Clay, for example, may not follow this pattern

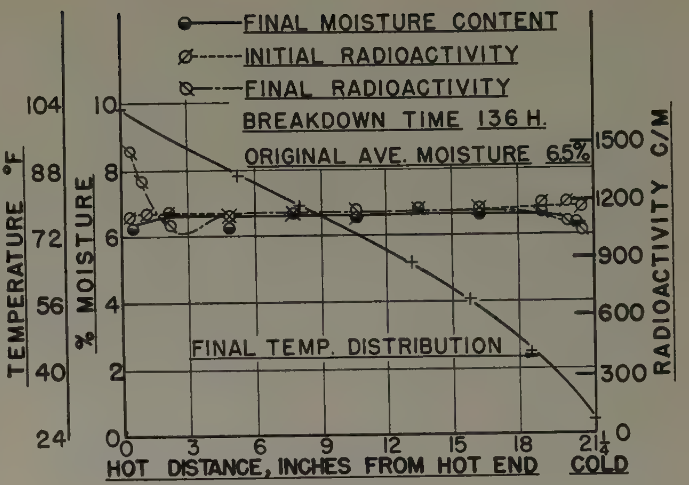

Figure 4. Run number 33: Temperature, moisture, and radioactivity versus distance, 0.01-inch bead

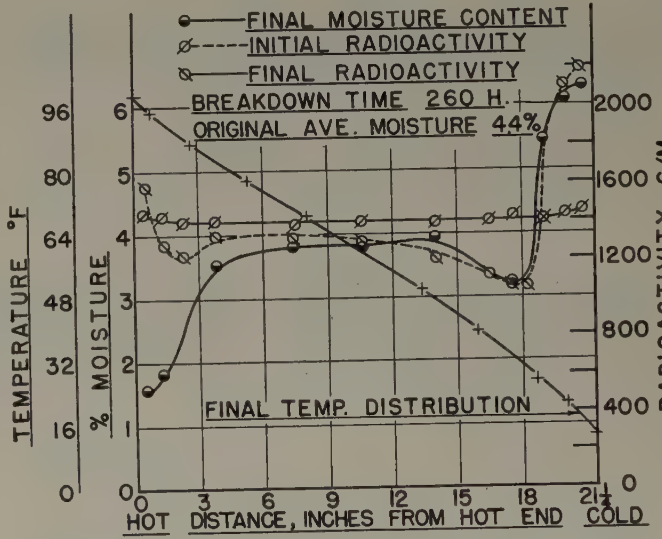

Figure 5. Run number 42: Temperature, moisture, and radioactivity versus distance, 0.001-inch bead

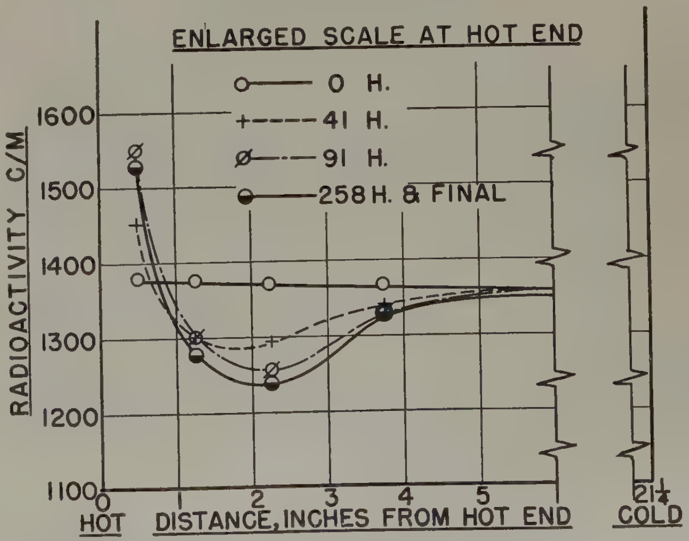

Figure 6. Data from run number 42: Radioactivity versus distance, 0.001-inch bead

at all and might not show a critical. It is hoped that this investigation can be extended to provide information on real soils (including clays) as to the numerical value of the critical, if it exists. The present investigation was conceived to produce 1-dimensional heat transfer while the circulation phenomenon is definitely a 2-dimensional effect. A 2-dimensional investigation in the future also might prove highly productive. At the present time it can be said that this critical condition probably exists in many real soils, but in which soils it exists can not be stated positively nor can the value of the critical moisture content for any real soils be stated. It would appear that if some real soils do not exhibit this circulation phenomenon, or if they customarily exist at a moisture content below the critical, they would be highly undesirable as material adjacent to underground transmission cable. More definite answers cannot be given at this time.

Appendix

It is highly improbable that there is an appreciable leakage of vapor from the hot end of the apparatus. In the first place the pipe containing the moist "soil" was tightly sealed by a closely fitte aluminum plug extending 1 inch into the pipe and all joints were fille with beeswax or Pematex gasket cement number 2. In addition t these, the final external joint was coated with self-vulcanizing liqui latex forming a tight-fitting external vapor barrier.

As additional evidence against evaporation, a series of runs wer conducted with a wet cloth placed between the Dewar Flask (used t insulate the pipe) and the outside of the pipe. The cloth was kep wet by water supplied from an external source and hence produced saturated conditions around the pipe containing the "soil." This should eliminate any tendency for vapor to leave the tube due to the resulting high external vapor pressure. There is no noticeable change in the radioactive rise at the hot end with or without the wet cloth.

Even if a small hole did exist to allow evaporation to the atmosphere, the amount of moisture that would diffuse is extremely small. Only 0.04 gram of water will diffuse through a 1/64-inch-diamete hole under the conditions of 121 degrees Fahrenheit inside and 77 degrees Fahrenheit and 60-per-cent humidity outside of the sample tube.

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A Complex Algebra for Relay Circuits

MATTHEW RASPANTI

A convenient method of applying symbolic logic to Montgomerie's algebra is presented together with an introduction to a complex notation for circuits in which contacts are connected in parallel with relay coils.

In 1938 Claude E. Shannon[1] showed how a perfect analogy existed between the calculus of propositions, a branch of symbolic logic, and an algebra for relay circuits based on the assumption that in a contact-making device the open contacts close and the closed contacts open simultaneously.

In 1948 G. A. Montgomerie,[2] without any reference to symbolic logic, developed an algebra for relay circuits that takes into account the transition period between the opening of the closed contacts and the closing of the open contacts.

The following notation will be used:

$a=b$..........Propositions "a" and "b" are equivalent
$a+b$..........."a" and "b"
$a\cdot b$..........."a" or "b"
$\bar{a}$.............not "a"
x.............The normally-open (no) contacts of device X are closed
x'............The normally-closed (nc) contacts of device X are closed
x_φ............Either the no or the nc contacts of device X are closed
x_Λ............Both the no and the nc contacts of device X are open
$E(X)$..........Relay X is energized

As long as 2-valued propositions are used to define the operating conditions of a relay, all the concepts of symbolic logic can be applied to Montgomerie's algebra, but Shannon's fundamental relation

$$x'=\bar{x}$$

must be replaced by the more general relations

$$x'\cdot x_\Lambda=\bar{x} \tag{1}$$

$$x\cdot x_\Lambda=\bar{x}' \tag{2}$$

$$x\cdot x'=x_\varphi=\bar{x}_\Lambda \tag{3}$$

If this basic fact is kept clearly in mind, it can be seen that some theorems can be extended from Shannon's algebra to Montgomerie's. Thus, for instance, Shannon's dual theorems

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$$xy+yz+zx'=xy+zx'$$
$$(x+y)\cdot(y+z)\cdot(z+x')=(x+y)\cdot(z+x')$$

are still valid if rewritten in the form

$$xy+yz+z\bar{x}=xy+z\bar{x} \quad (4)$$

$$(x+y)\cdot(y+z)\cdot(z+\bar{x})=(x+y)\cdot(z+\bar{x}) \quad (5)$$

The symbols x_φ and x_Λ were first introduced by Montgomerie to designate special contacts that are at all times respectively closed and open except during the operation of the corresponding contact-making device. A combination of an no and an nc contact in parallel can be used to realize the contact x_φ but no combination of contacts can be obtained that will give the operating characteristics of x_Λ as long as a relay is controlled only by a combination of contacts in series with its coil. The symbol x_Λ, therefore, does not have any physical meaning in Montgomerie's algebra and, whenever this symbol appears in the solution of a problem, an approximation must be made by means of special contacts.

It should be observed that a contact x_φ in parallel with a relay coil has the same effect as an imaginary contact x_Λ in series with the coil. This fact can be expressed by the notation

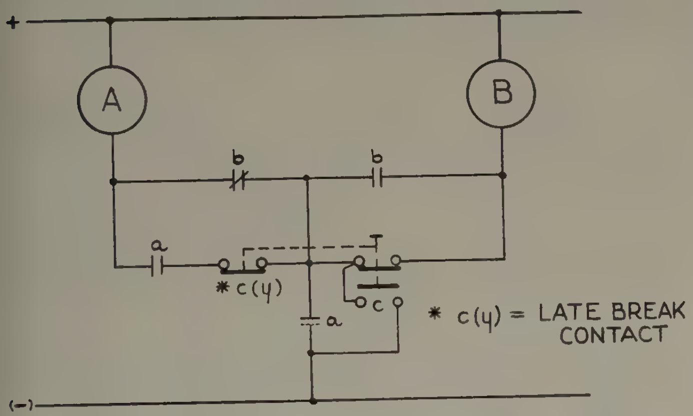

Figure 1. **Montgomerie's circuit**

$$x_\Lambda=jx_\varphi \quad (6)$$

Since

$$x_\varphi=\bar{x}_\Lambda$$

instead of equation 6 it can be written

$$x_\Lambda=j\bar{x}_\Lambda$$

More generally, it can be stated that any circuit in series with a relay coil has the same effect as its negation in parallel with the coil

$$f_1=j\bar{f}_1 \quad (7)$$

If a relay is controlled by a circuit f_1 in series with its coil and a circuit f_2 in parallel with the coil, the complex notation

$$f_1+jf_2$$

can be used.

The following theorems hold:

$$f_1+f_2=f_1+j\bar{f}_2 \quad (8)$$

$$(f_1+f_2)+jf_3=f_1+j(f_3\cdot\bar{f}_2) \quad (9)$$

$$f_1+j(f_2\cdot f_3)=f_1+\bar{f}_2+jf_3 \quad (10)$$

It may be of interest to see how some of the preceding considerations can be used to simplify the solution given by Montgomerie for the design of a circuit in which a relay A is required to operate the first time a pushbutton C is operated, to remain operated when C is released, and to release the next time C is operated. Figure 1 shows Montgomerie's complete circuit. The solution for relay A can be written in the form

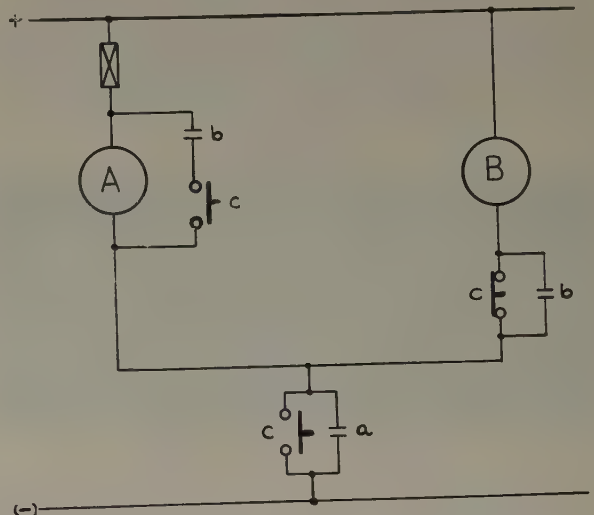

Figure 2. **Simplified circuit based on complex notation**

$$E(A)=ac+b'(a+c'c_\Lambda) \quad (11)$$

The special contact $c(y)$ of Figure 1 is necessary to approximate the requirement $c'c_\Lambda$. Multiplying out in equation 11 and applying equations 4, 1, and 8 gives

$$\begin{aligned} E(A)&=ca+ab'+b'c'c_\Lambda\\ &=ca+b'c'c_\Lambda=ca+j(\overline{b'\cdot c'c_\Lambda})\\ &=ca+j(\bar{b}'+c) \end{aligned} \quad (12)$$

It should be noticed that no b_Λ appears in equation 11; this indicates that the operation time of relay B does not affect the solution. It is then justified to put

$$\bar{b}'=b$$

in relation 12, which becomes

$$E(A)=ca+j(b+c)$$

The circuit shown in Figure 2 is then obtained. The number of contacts has been reduced and the necessity of special contacts eliminated.

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Miniature Fuses for Appliance Circuits' Protection

A. J. STEELE

This discussion of miniature fuses traces the development of miniature fuses, compares various types of fuses, compares the specifications for miniature fuses and service circuit breakers, and offers some recommendations which it is felt will be of definite benefit to both the fuse industry and the appliance industry in general.

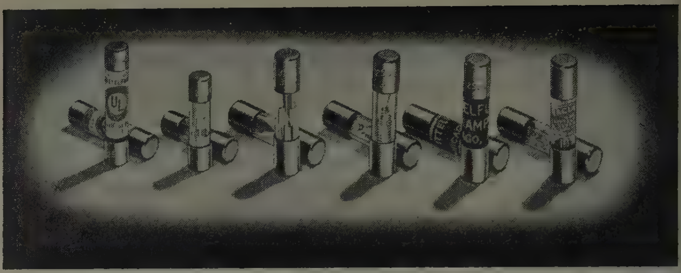


Figure 1. Cartridge fuses used for electronic communications and instrument protection

3AB—Underwriters' Laboratories approved fuse; 8AG—Instrument fuse; 4AG—Antivibration fuse; 4AG—Slo-blo fuse; 4AB—Aircraft fuse; 4AG—Instrument fuse (left to right, respectively)

MINIATURE FUSES, referred to in the industry as *3AB* fuses, are used in appliances for overload protection and short-circuit isolation. Much of the electric equipment in use today is protected by means of fuses at the equipment. This obviously gives the user greater protection against overload without the disadvantage or loss of the entire branch circuit should the appliance be short-circuited or overloaded. There is a great deal of similarity between this sort of application of fuses and the application of auxiliary or service-type circuit breakers. Both perform the same function. Therefore, the specifications for both miniature fuses and service circuit breakers will be compared.

In 1933 the *3AG* fuse ($1^{1}/_{4}$- by 1/4-inch diameter) was listed and approved by Underwriters' Laboratories from 0–3 amperes at 250 volts. In response to the request of the electronic and appliance industries and through the engineering efforts of several companies, the range of approved fuses was increased to 8 amperes at 250 volts by 1938. Using a glass body in a fuse, it becomes difficult to withstand the short-circuit requirements of Underwriters' Laboratories above 8 amperes in rating. Underwriters' Laboratories specifies that the test circuit used in short-circuit tests shall be of a sufficient capacity to deliver 10,000 amperes at 250 volts direct current. A fuse subjected to this test must remain intact without producing sufficient flame or molten metal to ignite surgical cotton which completely surrounds the fuse. Due to extreme pressures generated at the time of short circuit, the glass body in some of the fuses shatters. At this point, an attempt was made to use bakelite and fuse fiber in the manufacture of a fuse that would be capable of handling high amperes under the short-circuit conditions. This was the *3AB* ($1^{1}/_{4}$- by 1/4-inch diameter) fuse line, see Figure 1.

During the war a great deal of experimentation was made and steatite became the body material for a new line of *3AB* fuses. The steatite body gives a great deal more strength than the bakelite or fuse fiber and is also less hygroscopic. With the use of steatite bodies, ratings were extended up to 15 amperes at 250 volts. This represents the maximum that Underwriters' Laboratories will approve due to the classification limits.

Fuses have been made that will meet all of the test requirements up to 20 amperes at 250 volts. The Navy is currently testing 30 amperes at 125 volts with 25,000 amperes available. It should be pointed out at this time that the continuous current-carrying capacity of conventional fuse clips for 1/4-inch diameter fuses is approximately 20 amperes, if temperature on the fuse clip is not to exceed 70 degrees centigrade maximum. Beryllium-copper silver-plated fuse clips are recommended for 20 amperes and above.

Specifications on fuse-blowing characteristics have evolved gradually, over a period of years, into three general classifications: (1) a fast-blowing fuse is required to protect properly instruments and delicate electric mechanisms; (2) a medium-lag fuse is used for protecting wiring and is ideal for appliance applications; (3) the "slo-blo" is just as the name implies—a fuse with a slow-blowing characteristic or high lag. This fuse is used in motor protection and circuits having a high surge characteristic which greatly extends the continuous current-carrying ability of the average fuse. The *3AB* fuse, being a medium-lag fuse, is ideal for electric appliance applications. All of the *3AB* fuses, as well as the *3AG* fuses, see Figures 2 and 3, must meet the following overload specifications:

Percentage Overload Current	Maximum Blowing Time in Minutes
200	2
135	60

In addition the fuse must be capable of carrying 110 per cent of rating indefinitely. In general, medium-lag fuses are used for power supplies, either in the primary or secondary; battery chargers; and for communications equipment generally. There are several hundred thousands of these fuses used in these applications at the present time. The author has no knowledge of any report of failure. This seems to speak very well for the design of the fuse.

In the application of the *3AB*-type fuse, there is a great deal of similarity with the auxiliary or service-type circuit breaker. These circuit breakers, like the *3AB* fuses, are used for the protection of appliances and equipment circuits and are not expected to meet the same requirements as the branch-circuit-protection devices. It is believed that there is an element of unfairness and inconsistency existing in that the specification in which the short-circuit test requirements for service circuit breakers of 100 amperes and lower is less than that to which the *3AB* type of fuse is subjected. Therefore, a direct comparison of the specification that applies to the circuit breakers and to fuses is made here. The specification for short circuit of the service circuit breaker is

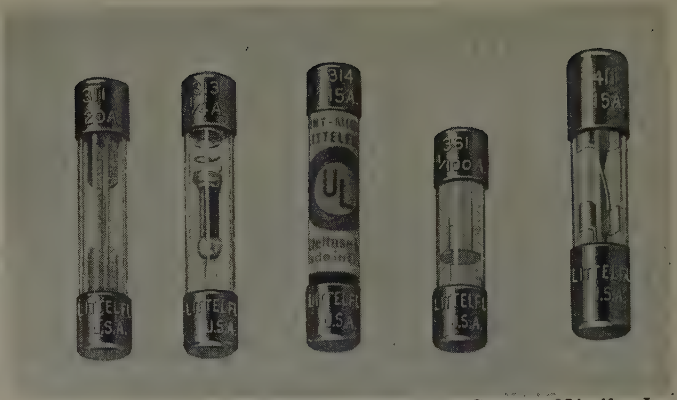
> The current capacity of supply circuits together with a total limiting resistance or impedance of the circuit should be sufficient so as to permit a current blow of not less than 5,000 amperes for a breaker rating at 100 amperes or less and 250 volts or less and not less than 10,000 amperes for a breaker rating at more than 100 amperes or for any rating of more than 250 volts.

The specification for short circuit of the special cartridge fuses is

> The source of supply and the test circuit are to be of sufficient capacity to deliver 10,000 amperes when the system is short-circuited by means of a copper bar 2 inches wide and 1/4 inch thick connecting the 600-ampere fuse-holder terminals.

It is held that both products are used in a great many cases in the same applications and therefore they should have the same sort of short-circuit specifications. It will be noted that the circuit breaker has 5,000 amperes short circuit while the fuse of lesser rating has 10,000 amperes short-circuit current. If this fuse should be subjected to the same specifications that are required for branch circuit protection, it should be allowed to be used as branch circuit protection or be tested at a more realistic test condition. Therefore, the following recommendations are made:

1. Inasmuch as the *3AB* fuse must stand up under the same test as branch circuit fuses, it is felt that they should be allowed the same privilege of applications as the branch circuit fuses. This would tend to maintain the high quality standard of this particular fuse and allow greater utilization of the *3AB* fuse.
2. It is believed that the quality of the product should be maintained at its present high level. However, if the fuse is not able to enjoy the privileges of application comparable to branch circuit fuses, it is recommended that the test specification of Underwriters' Laboratories be made comparable to that of auxiliary or service-type circuit breakers. It would appear that the applications are similar and therefore the specifications should be comparable.



Courtesy of Littelfuse Inc.

Figure 2. Typical design of cartridge-type fuses

3AG—Plain-element fuse; 3AG—Slo-blo fuse; 3AB—Underwriters' Laboratories approved fuse; 8AG—Instrument fuse; 4AG—Antivibration fuse (left to right, respectively)

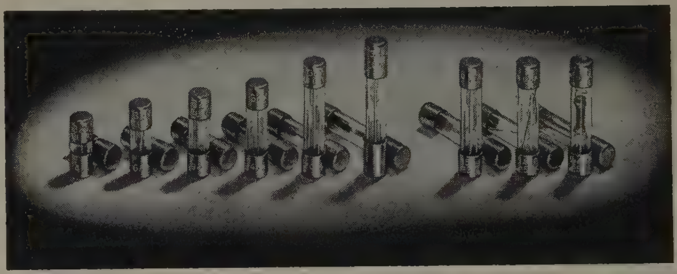


Figure 3. Typical cartridge fuses

4-ampere SFE; 6-ampere SFE; 9-ampere SFE; 14-ampere SFE; 20-ampere SFE; 30-ampere SFE; 3AG—Element-type fuse; 3AG—Filament-type fuse; 3AG—Slo-blo fuse (left to right, respectively)

Full text of a conference paper presented at the AIEE Conference on Domestic Appliances, Louisville, Ky., April 22–24, 1953, and recommended for publication by the AIEE Committee on Domestic and Commercial Applications. Part IV of a series; Part I "Motor Overload Protection for Domestic Appliances" appeared in the August issue, pages 694–6; Part II "Branch-Circuit Overcurrent Protection for Appliance Loads" in September, pages 778–9; and Part III "Role of Fuses in Appliance Protection" in October, pages 901–03.

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Alarm Keyer Approved

The Federal Communications Commission has granted approval to the Radiomarine Corporation of America on its alarm signal keyer, model *AR-6862*. The device is used for transmission of the international alarm signal and distress signal. The alarm signal keyer is required to be fitted on all compulsory nonportable lifeboat radio equipment by November 19, 1953.

Model *AR-6862* is designed for use within the existing type of lifeboat equipment and for use with any other type of equipment having similar operating requirements.

A Million-Watt Naval Communication Transmitter

J. C. WALTER
MEMBER AIEE

THE MOST POWERFUL radio-telegraph transmitter ever built for the United States Navy is conservatively rated at 1,000 kw output over the 15- to 35-kc frequency range. Its use will ensure reliable communication with the United States Fleet even when high-frequency services are interrupted by magnetic disturbances.

Unique features include the first use of super-power electron tubes having a power gain of at least 250; 10-microsecond fault protection; a variable master oscillator with 0.001-per-cent frequency stability; and provisions for frequency-shift teletype signalling.

Known as the Model *AN/FRT-3* Radio Transmitting Set, the basic transmitter consists of: transmitter units in compartmented shielding; supervisory console; frequency generator-monitors; auxiliaries; cooling systems; water-cooled test loads; and antenna tuning equipment.

An efficient catenary antenna system was specially designed for suspension between two mountain ridges. A radial system of buried ground conductors contains nearly 200 miles of copper wire.

The transmitter comprises identical port and starboard units symmetrically disposed about a central control section. For full-power operation both power amplifiers are driven by either exciter and either frequency generator-monitor may be used to furnish keyed signals to the exciter in use.

Supervisory console elements include extension controls and instruments for trimming amplifier and antenna circuits. Selector switches in a mimic bus control various cross-switching operations.

Each exciter is a broad-band amplifier requiring no tuning adjustment over the rated frequency band. The output stage is coupled to either or both power amplifiers through an iron-core oil-cooled transformer.

A general view of the port power amplifier radio-frequency circuit elements is shown in Figure 1. The coil assembly includes two motor-operated variometers and manually adjustable output coupling inductors.

Tuning of the conventional push-pull plate tank circuit is accomplished by push-button control of the plate variometers. Two of the three type *5831* super-power tubes supported in their toroidal filament transformers are active. The third is an installed spare which may be quickly switched into service in lieu of either active tube. Type *5831* tubes require exceptionally low driving power. Their use makes possible a considerable saving in both transmitter construction and operating costs.

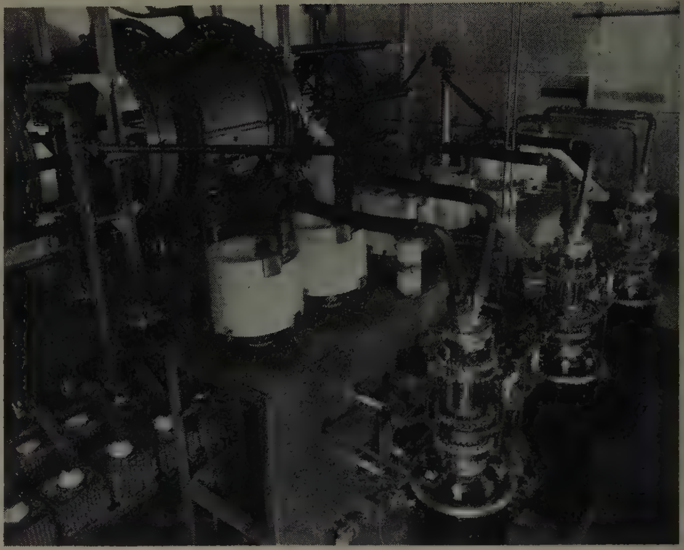

Figure 1. Power amplifier tubes and radio-frequency circuit elements. Output coupling coils are in center of plate variometer assembly

A tube protective unit built into each power amplifier is a high-speed electronic control device used to protect the amplifier tubes from damage due to internal gas arcs or similar faults. Whenever there is a sudden rise in power amplifier tube current above normal the d-c plate supply bus is grounded through a type *5630* ignitron. This protection is applied 7 to 10 microseconds after the fault is initiated.

Port and starboard antenna tuning equipments each consist of a motor-operated variometer and two helix assemblies wound with Litzendraht conductor. The series loading helices are approximately 14 feet in diameter by 26 feet high with windings assembled on stacked porcelain spacers. Currents of approximately 1,000 amperes in each antenna half are anticipated at the lower operating frequencies and voltage at the top of the helices is expected to approach 200 kv.

Design of the antenna/ground system was based upon topographic limitations peculiar to the installation site. Each half of the antenna consists of five catenary suspensions supported from 200-foot steel towers erected on opposing mountain ridges providing five separate flat-top capacity elements having an average elevation of approximately 1,000 feet over the valley floor. A downlead from each flat-top section is connected to a common radio-frequency feeder bus connecting the transmitter output to the radiating system.

Tests were conducted during 1950 at Camden, N. J., where the transmitter was assembled in its test position. Output powers up to 1,200 kw were dissipated in the water-cooled test loads. Full power keying tests at speeds up to 160 dot cycles per second (400 words per minute) revealed no signs of instability.

Digest of paper **53-199**, "A Million-Watt Naval Communication Transmitter," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Frequency Generating Equipment for Transmitter

D. G. ROBERTSON
MEMBER AIEE

NOVEL METHODS are used to obtain crystal stability and still permit continuous coverage of the frequency range. The type *O-146/FRT-3* Frequency Generator-Monitor described is part of the Navy's new Model *AN/FRT-3* super-power very-low-frequency transmitter.

Equipment described meets the following general specification requirements: the generation of a radio-frequency signal continuously variable from 14.5 to 35.0 kc with a frequency stability of 0.001 per cent; an on-off keying capability of speeds up to 75 cycles per second without the use of relays when polar or neutral keying signals are supplied; a frequency-shift keying capability, either polar or neutral, with deviations up to ±25 cycles at speeds up to 24 cycles per second; and provision of control circuits to place the transmitter in a stand-by condition after keying signals have stopped for an adjustable, predetermined period. The equipment designed to meet these requirements is called the Frequency Generator-Monitor.

Basic equipment consists of two variable-frequency sources, a master oscillator, and a monitor. Auxiliary equipment is included to compare the two frequencies. This consists of a deviation indicator which measures and records the difference between the two frequency sources and an automatic frequency-control circuit which provides a means of continuously correcting the master oscillator frequency to that generated by the monitor. Elements mounted in the left bay of the equipment shown in Figure 1 and the upper unit of the center bay comprise the master oscillator. Second and third units in the center bay are the deviation indicator and automatic frequency-control elements respectively. The remaining elements constitute the monitor.

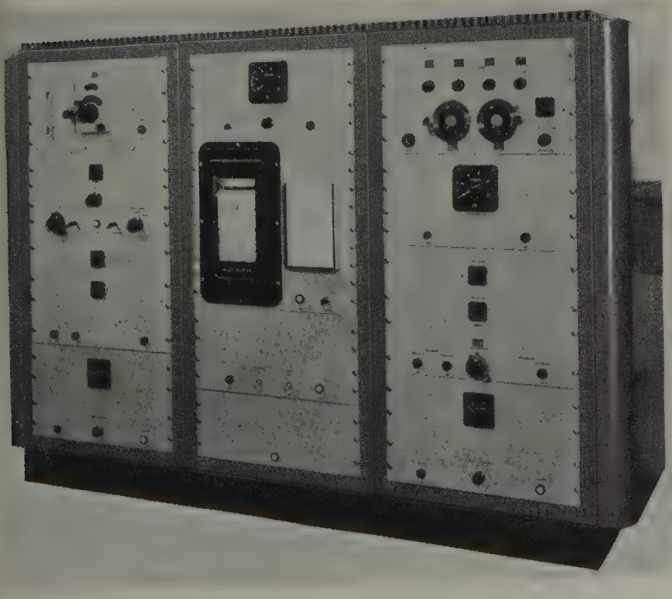

Figure 1. Frequency Generator-Monitor

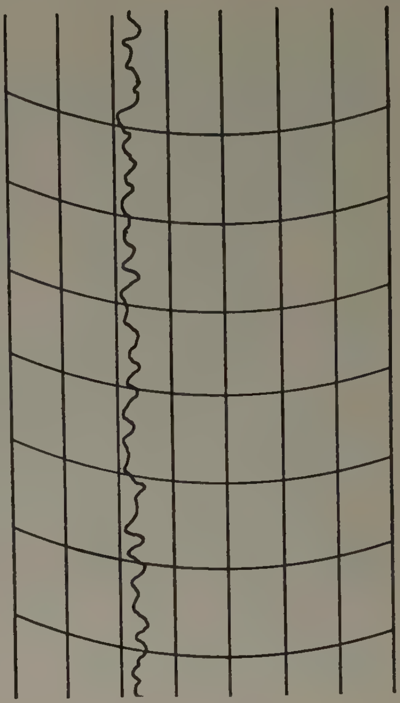

Figure 2. Master oscillator frequency stability with automatic frequency control. Horizontal scale is 0.4 cycle per division. Vertical scale is 6.0 minutes per division

The master oscillator provides a radio-frequency voltage to drive the transmitter by heterodyning the 214.5- to 235.0-kc output of a variable oscillator with the output of either of two crystal oscillators and using the difference frequency. A fixed 200-kc crystal oscillator modified by a reactance tube up to ±25 cycles per second is used for frequency shift keying. The master oscillator also includes all necessary mixer, amplifier, and keying circuits.

The circuits which comprise the monitor have the sole function of generating any frequency over the range of 14.5 to 35.0 kc and maintaining it within the specified tolerance of 0.001 per cent. This is accomplished through the use of a binary-type variable-frequency divider and a highly stable crystal oscillator. The variable-frequency divider, by means of selector switches, can be set to divide by any whole number between 6,450 and 8,500 and is independent of frequency. This permits the generation of any frequency over the desired range with the stability of the crystal oscillator.

Figure 2 shows the frequency stability characteristics of the master oscillator when operating with automatic frequency control. Since the horizontal scale is 0.4 cycle per division and the run was taken at a frequency of 22 kc the total variation shown is 0.00032 per cent.

Digest of paper **53-198,** "Frequency Generating Equipment for Million-Watt Navy Transmitter," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions,* volume 72, 1953.

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Substation 1-Line Diagrams

AIEE COMMITTEE REPORT

The scope of this article was to investigate the basic primary circuit electrical configurations for transmission and distribution substations. This study was made broad because, until voltage ratings have been assigned to the circuits in a substation diagram, it represents equally well the lowest to the highest voltage circuits.

ELECTRICAL engineers could paraphrase the proverb, "One picture is worth a thousand words," by stating, "A 1-line diagram is worth ten thousand words." Any one who has had the responsibility of either preparing specifications or reading with understanding specifications on substations prepared by others will fully understand what is meant. The 1-line diagram is the medium of thought transference from the written word of the specification to the picture that can be readily visualized of the course of power through any substation no matter how simple or elaborate.

National Electrical Manufacturers Association (NEMA) Power Switching Assemblies Standard *SG5-1.53* defines a 1-line diagram as follows: "A 1-(or single-)line diagram is a diagram which indicates by means of single lines and simplified symbols the route and component devices or parts of an electrical circuit or system of circuits. Physical relationships are usually disregarded."

However, the scope of this article is not to extol the virtues of 1-line diagrams but to investigate and study the basic primary circuit electrical configurations for transmission and distribution substations. This scope of necessity has been made broad because, until voltage ratings have been assigned to the circuits in a substation diagram, the diagram for what it represents will apply equally from the lowest to the highest voltage circuit.

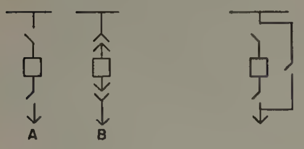

Figure 1A (left). Diagram of single feeder circuits of switchgear with stationary mounted breakers. Figure 1B. Diagram of metal-clad switchgear with removable breakers. Figure 2 (right). By-pass switch around power circuit breaker

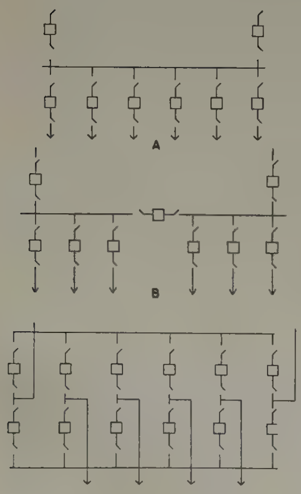

Figure 3A (top). Single- or main-line bus. Figure 3B. Sectionalized single bus Figure 4 (bottom). Double main-line bus

The development of the basic diagrams starts from the necessary equipment needed to control and service a feeder with the added thought that as two or more feeders are bussed, additional complications may occur. While equipment trouble usually will involve only one feeder circuit, bus trouble can shut down all feeders connected to it.

The usual equipment requirements for a feeder are a power circuit breaker and disconnecting means for isolating purposes. The basic 1-line diagram of this circuit for switchgear with stationary mounted circuit breakers is shown in Figure 1*A* and for metal-clad switchgear with removable breakers in Figure 1*B*. The diagram in Figure 2 shows a by-pass switch around the power circuit breaker for circuits in which no other means are available to release breaker for service maintenance.

From the simple principles illustrated by these circuits, the entire group of substation diagrams can be developed. Generally speaking, almost any circuit that has the required current capacity will carry the load normally but it must be further analyzed from the following points of view:

1. How can the substation equipment be maintained without a service interruption of load carried, or danger to personnel?
2. How quickly can service be restored in case of apparatus trouble?
3. How can the substation be expanded to meet future load growth?

In the electrical industry, a high value has been placed on service continuity and in many instances the public has been educated to expect perfect continuity with the result

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Personnel of Working Group on 1-Line Diagrams, AIEE Committee on Substations: E. M. Hunter, *Chairman*, General Electric Company, Schenectady, N. Y.; T. J. Allen, Georgia Power Company, Atlanta, Ga.; H. Bany, General Electric Company, Philadelphia, Pa.; R. O. Bell, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; H. P. Cadario, Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada; M. V. Eardley, Water and Power Department, City of Los Angeles, Calif.; H. F. Gidlund, Public Service Company of Colorado, Denver, Colo.; S. C. Killian, Delta-Star Electric Company, Chicago, Ill.; R. F. Stevens, Bonneville Power Administration, Portland, Oreg.

that many substations have been loaded with contingency devices, the need for which, with reliability of present station equipment, is open to question.

It is the practice in many quarters to examine critically existing substation design practices from the viewpoints of

1. Does it complicate the substation layout?
2. How often and under what contingency is it used?
3. Does it introduce additional hazards which may outweigh the advantages it is intended to provide?

A substation may be so encumbered with contingency devices that it becomes difficult to operate it with safety; and in a real emergency mistakes in operation are likely to be made. Safety starts with the basic 1-line diagram. As the causes of the major portion of former outages have been remedied by improvements that have taken place in breaker design, it is no longer necessary to provide all the precautions that had to be taken in the early days of the art.

Disconnecting switches used for other than isolating purposes are questioned. In the past, a by-pass switch provided the comfortable feeling that it would carry the load, whereas this feature in a circuit breaker was questionable. Today such by-pass switches, having no interrupting ability, are designed out of a substation wherever possible with the approach that such by-passing must be done with breakers.

It is to be acknowledged however, that for some applications the by-pass switch is still the proper solution, like, for example, the single feeder circuit of Figure 2. By-passing of a feeder breaker with a duplicate breaker on an outdoor station obviously would be preferable to a switch except that the cost of the circuit breaker cannot ordinarily be justified. The breaker by-pass switch is inexpensive and although the feeder may be without relay protection while the by-pass is closed, this small risk is usually preferable to the expense of a duplicate breaker. If the substation has two feeder breakers, arrangements sometimes can be made for one breaker to carry both circuits while the other breaker is out of service for maintenance.

It is to be remembered that the 1-line diagram of a given station is but a part of a larger and more complex diagram which includes the whole connected electric system. The station diagram must not be studied independently, but in connection with the larger system, if the best station 1-line diagram is to be selected. For instance, a considerable investment in spare equipment and busses may be justified in a station which is the sole source of power, for an important load, which would not be justified if alternate sources were available from other stations.

When a feeder is directly associated with a power transformer or several feeders are grouped on a bus, it is termed a substation. American Standard *35.40.240* defines an Electric Power Substation as follows:

> "An electric power substation is an assemblage of equipment for purposes other than generation or utilization, through which electric energy in bulk is passed for the purpose of switching or modifying its characteristics. Service equipment, distribution transformer installations, or other minor distribution or transmission equipment are not classified as substations.
>
> *Note:* A substation is of such size or complexity that it incorporates one or more busses, a multiplicity of circuit breakers, and usually is either the sole receiving point of commonly more than one supply circuit, or it sectionalizes the transmission circuits passing through it by means of circuit breakers."

Again it is to be noted that no reference is made to the kilovolt-ampere capacity or voltage in the definition, so these factors cannot be used as the criterion in classifying substations, although they are some of the most important items to be considered before the basic design can be selected.

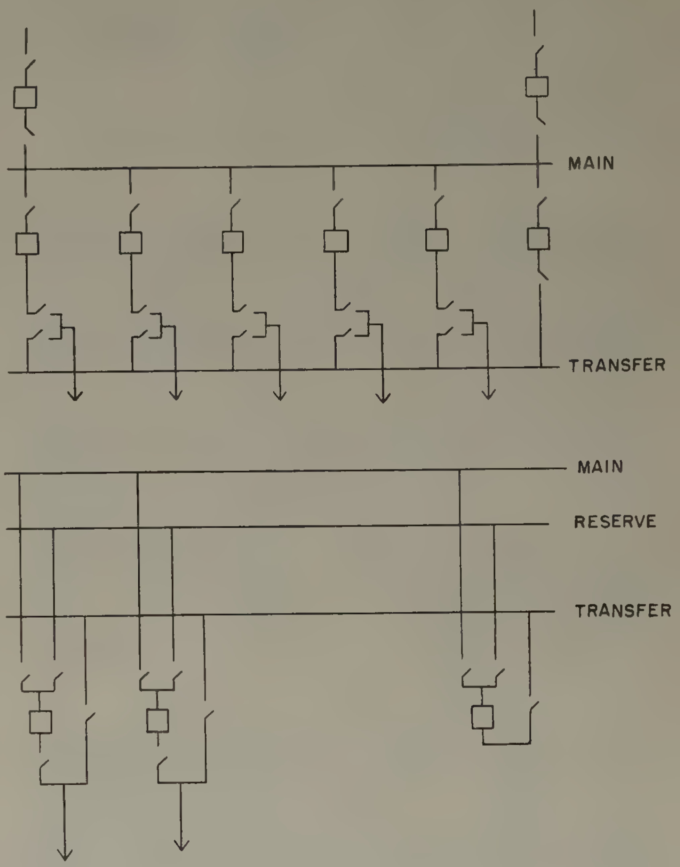

Figure 5 (top). Main and transfer bus. Figure 6 (bottom) Main, reserve, and transfer bus

There are many types of substations resulting from duplication of busses, power circuit breakers, and varieties of disconnecting switches. Some of the basic diagrams will be reviewed.

TRANSMISSION SUBSTATIONS

Single or Main Bus. This substation has a number of feeders grouped together on a single bus, as shown in Figure 3*A*. Substation service continuity depends upon maintaining the integrity of this bus. This substation has low cost and is used widely. It is generally limited to those systems where loads can be fed from more than one source in times of emergency. It is this feature in the system that is used to provide service continuity when the substation is down for maintenance or in trouble.

The substation is simple to operate as it has the minimum in equipment complication.

Sectionalized Single Bus. This scheme, Figure 3*B*, is the same as the one previously described, except that the bus is divided into two or more sections by the use of one or more bus sectionalizing circuit breakers. Each of the latter normally will have two associated isolating disconnecting switches. This scheme has the advantage that any section of bus can be taken out of service for maintenance without affecting other bus sections or their connected feeders. Likewise, differential relaying can be provided so that a fault on any bus section will not take out the others.

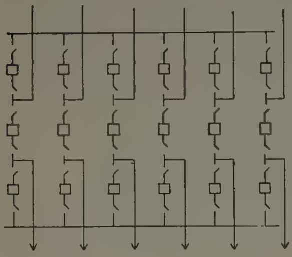

Figure 7. Breaker and a half scheme

For best use of this scheme, incoming circuits (and also outgoing circuits) should be divided among the bus sections as evenly as possible. When the circuits are properly arranged, and the load factor and normal circuit loadings are not too high, it is often possible to schedule outage of a bus section for maintenance at light load periods without dropping any load. (This obviously will not apply to loads fed only from a single radial feeder from the bus taken out of service.)

Double Main Bus. In those applications when it is desirable to duplicate facilities in the substation, the double main bus is used, as shown in Figure 4. Each load can be fed from either bus. If such a substation layout is to be used, it should be pointed out that adequate physical separation must be planned for the busses. To place these main busses, for example, one above the other, is in effect nullifying the basic feature of duplication because a fault in one bus more than likely would involve both.

Duplicate facilities double the cost of bus and switching and the extra expense probably is justified only for major high-voltage stations, or stations serving unusually important loads.

The scheme, though costly, is simple and straightforward, tending to minimize the chance of operating errors, particularly since all switching is done by breakers. A breaker or bus can be taken out of service at any time without loss of line relay protection. If both busses are kept energized normally, a fault in either bus can be cleared by differential relays without loss of service.

The standard basic double-bus scheme can be modified in a number of ways. One or both busses can be divided into any number of sections desired, using bus sectionalizing breakers with isolating disconnecting switches.

Double breakers may be used for some circuits, whereas other circuits may be connected to one bus by means of a circuit breaker, and the other through a disconnecting switch only. Choice may be determined in each case by the importance or the amount of exposure of the particular circuit and the possibility that the second breaker cannot be justified now but may be necessary sometime in the future.

Main and Transfer Bus. A transfer bus is one to which one circuit at a time can be transferred from the main bus, as shown in Figure 5. It provides a means for servicing the feeder breakers. In the event of main bus trouble, the substation is down because the transfer bus must receive its power from the main bus unless a bus sectionalizing switch is included or the incoming or source circuits are arranged through additional disconnecting switches so that they may be connected to either the main or transfer bus.

Load transfer from the main to the transfer bus is done by disconnecting switches after the bus tie breaker is closed. Care must be exercised in operating the disconnecting switches in the proper sequence, or they should be interlocked to prevent operation under load.

Main, Reserve, and Transfer Bus. A reserve bus usually is understood to be one to which any or all of the feeders and incoming power sources can be connected. It functions as a second main bus, see Figure 6. Frequently feeder loads are distributed on the two busses, each with its own transformer feed for normal operation so that one bus fault will not cause a complete outage.

Lower interrupting capacity feeder breakers may be used with this scheme since the short-circuit capabilities of only one transformer bank need be considered for normal operation. When two feeder breakers are provided for each bank, bank switching to assure minimum transformer losses can be done by supervisory control.

Breaker and a Half Scheme. The arrangement of Figure 7

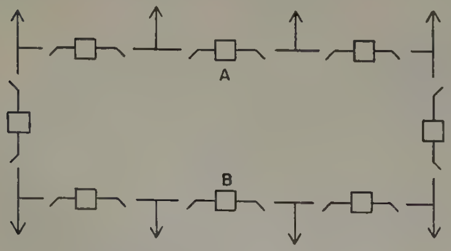

Figure 8. Ring bus

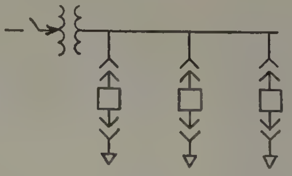

Figure 9. Radial substation

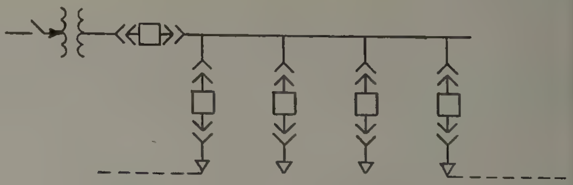

Figure 10. Primary network substation

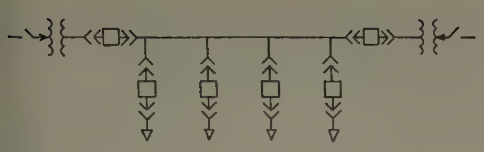

Figure 11. **Spot network substation**

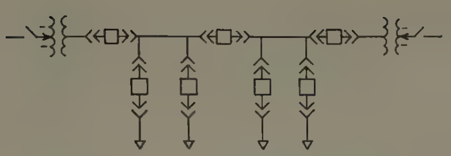

Figure 12. **Low-voltage selective**

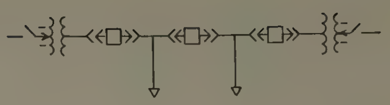

Figure 13. **Duplex substation**

provides the facilities of the double main bus at a reduction in equipment cost by using three breakers for two feeders. All load transfer is done by breakers and the operation sequences are simple. However, the relaying is somewhat more involved as the third breaker must be responsive to troubles on either feeder in the correct sequence.

Ring Bus. At first glance, the ring bus of Figure 8 appears to be ideal for a layout because each feeder has two sources of supply, any breaker can be removed from service for maintenance, and all switching is done with breakers. However, it has a serious weakness in that on double contingency faults, the entire station may be out of service. For example, if for any reason breaker *A* is open, the opening of breaker *B* will interrupt service to all of the feeders between breakers *A* and *B*. This feature certainly puts a limitation on the number of feeders that should be placed on a ring bus and is determined by the relative number of lines and feeders. For stations having not over four to six lines, it may prove to be a very feasible scheme to use.

DISTRIBUTION SUBSTATIONS

The trend in distribution substations has been to those which are relatively small in size, placed close to the load to reduce the length of the heavy secondary copper feeder circuits. Likewise, simplification in layout has been the rule, with the substation and system designed as a unit to provide the necessary facilities during emergencies. The factory-assembled substation, with its metal-clad switchgear, has been used widely. Disconnecting switches for other than isolating purposes have been discouraged in metal-clad gear and, in general, there have been fewer applications of them in distribution substations. Whether the substation is factory or field assembled, the design trend is still toward the use of simple standardized components that permit ordering of structures and equipment in quantity.

Radial Type. This substation with the single or main bus is widely used. See Figure 9. It is simple to operate and has low cost. It is obvious that bus trouble will shut the substation down. Likewise, there are no by-pass facilities in the substation for breaker maintenance.

Except for small isolated rural stations, this type of substation should be limited to that part of a system where the loads are carried on an open network type of system. The duration of an outage resulting from breaker trouble or planned maintenance may be minimized by carrying a spare breaker in the station, or a spare breaker in a service shop for several similar stations which can be substituted for the breaker being serviced.

Service continuity is improved by automatic reclosing of the feeder breakers as a majority of the faults are of the nonpersisting type.

Primary Network. The primary network system of Figure 10 is used when the load density and the geographical distribution of the load permits the feeders to be networked. When each feeder is operated in a closed network, any single set of feeder equipment or the entire substation can be isolated.

The transformer breaker is relayed to trip for power flow back into the subtransmission system and to reclose automatically upon restoration of voltage of the correct phase rotation.

Spot Network Type. The spot-network substation shown in Figure 11 provides a very high degree of service continuity. It is applied in those areas wherever a momentary outage is not advisable. In the event of a transformer or high line supply failure, the associated transformer breaker opens and the load continues to be served from the other transformer. However, provision must be made for a compromise voltage regulation for the period that the entire load is on one transformer.

Low-Voltage Selective Type. The low-voltage selective type of substation has its application when feeders of like characteristics can be grouped on a bus, see Figure 12. For example, residential and industrial feeders normally could be segregated and brought together only through the loss of a high line or a transformer. The tie breaker is normally open but is relayed to close automatically upon loss of voltage on either bus. Likewise it reopens when voltage is restored.

During the time the two busses are tied together, voltage regulation may digress from prescribed standard limits but usually is considered sufficient for the emergency.

Duplex Type. The duplex substation, see Figure 13, is usually applied when simplicity of the radial-type substation is desired and where individual feeder regulation is advisable due to the differences in the character of the loads and where added service continuity is demanded. It is the familiar breaker-and-a-half scheme with the bus-tie breaker normally open. In case of a transformer outage or a transmission-line failure, the combination feeder-and-transformer-secondary breaker associated with that side of the substation opens and the tie circuit breaker closes. This immediately restores service to both feeders through the remaining transformer.

It is to be noted that this substation arrangement provides means for servicing any component part without a service interruption and all of the switching done by breakers. This requires transformers with an emergency rating equal to the combined loads of the two feeders.

Double-Duplex Type. The double-duplex substation, see Figure 14, is a modification of the duplex substation and is different in this respect. The duplex substation equipped with load-ratio control transformers, provides individual feeder voltage regulation. The double-duplex substation with two feeders on a transformer bus provides bus regulation. A choice between these two substations should not be made without fully evaluating this difference.

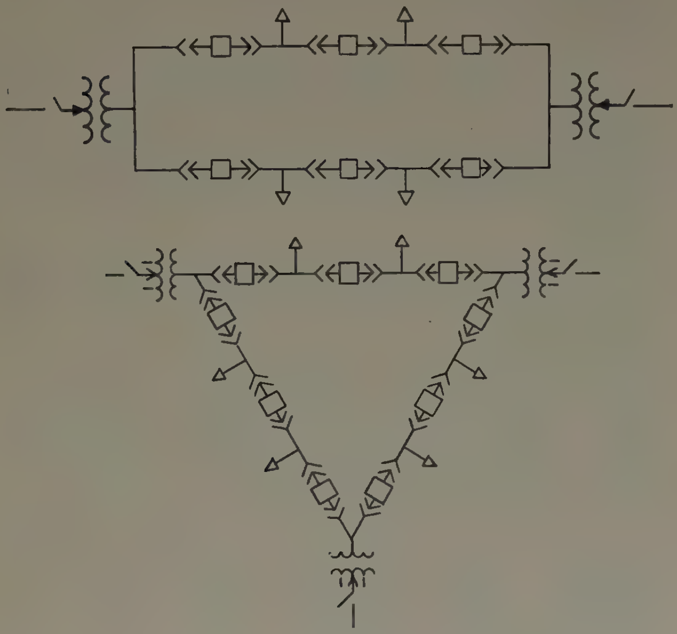

Figure 14 (top). Double duplex substation. Figure 15 (bottom). Multiplex substation

Individual feeder regulation is somewhat more expensive but the added expense is often justified.

Multiplex Type. The multiplex substation of Figure 15 is a further modification of the duplex substation. It is similar to the double-duplex substation inasmuch as two feeders are regulated as a unit. It differs from either the duplex or double duplex in the event a transformer is removed from service, its load is picked up by two rather than just one transformer.

Regulator Reactor Transfer Bus. The arrangement of Figure 16 is used when individual feeder or individual phase regulation is desired on each feeder. To service a feeder breaker or regulator, the load is transferred to the transfer bus. Since this switching is done with switches, the proper sequence must be followed or one of the switches will be opened under load. Because of this feature, this arrangement has not been popular in metal-clad switchgear.

In a few applications with metal-clad switchgear the switches have been equipped with load interrupters. The switching sequence is arranged so that normally these switches do not open load current but in the event of a misoperation, the operator has some protection, provided, of course, that the circuit is not faulted also.

Subtransmission Substation. This substation consists of two power transformers, two transformer secondary breakers, two busses each with several breakers and breaker by-pas facilities, and a bus tie breaker. See Figure 17.

For each outgoing feeder position there is also a circuit breaker position on the other bus to permit the feede to be fed from either bus by the transfer of a breaker. Th two breaker positions per feeder are relayed from a commo panel in one of the breaker houses.

A transformer, a bus, or a feeder breaker may be isolate for planned maintenance or repairs without a service interruption with the use of a spare breaker. All switching or transferring of feeders is done by power circuit breakers The busses are physically separated.

The substation can be converted to a double-bus double- breaker station by the simple addition of a second breaker in each of the present empty breaker positions if the service continuity requirements of the load warrant it in the future.

SUMMARY

THE BASIC 1-line diagrams outlined herein are those most commonly found in practice today. It is com-

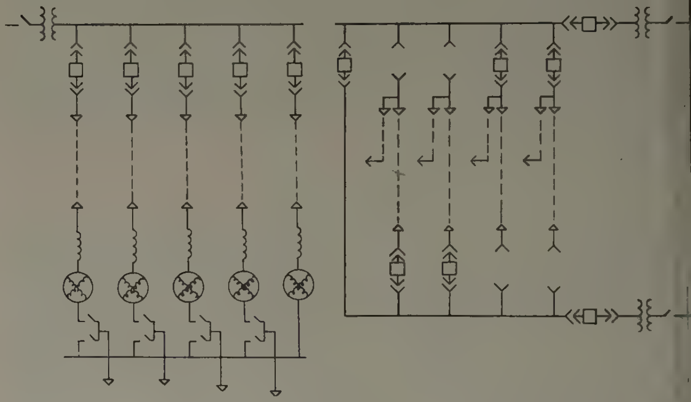

Figure 16 (left). Regulator reactor transfer bus substation Figure 17 (right). Subtransmission substation

mon system planning practice to adopt a system and a substation that best meets the application requirements and use these substations extensively. With the substations all alike, the chances of misoperation are reduced. This trend towards simplicity is such that in emergencies no time need be lost in deciding what the next step should be. The first step in any plan of this kind is to establish the basic 1-line diagram.

No attempt has been made in this review to bring in anything on the physical layout of the substation. The importance of this phase of substation design cannot be minimized because a return bus or crossover that may appear simple on the 1-line diagram, is not so simple in the actual substation. Consideration of this feature, however, was beyond the scope of the study.

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Tests of Fittings on Insulated Aluminum Cable

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BECAUSE OF increasing interest in the use of aluminum in insulated cables, information has been needed concerning factors of importance in the design and application of fittings for terminating, tapping, and splicing insulated aluminum cables. Information also has been needed concerning the suitability of commercially available fittings for such conductors. Since 1948 many tests have been made of fittings on insulated aluminum cables of a wide range of sizes, in the Electrical Conductor Laboratory of Aluminum Company of America at Massena, N. Y.

Much of the testing has been done by means of "heat-cycling" assemblies of fittings on cables. In such testing the assemblies have been alternately heated by the passage of current and allowed to cool with no current flowing. The current values selected for the heating cycles for most of the tests have been the maximum conductor current ratings allowed by the National Electrical Code for single aluminum cables of the appropriate size with type *RH* insulation in free air. Test fittings have been applied on lengths of cable with "current equalizers" mid-way between adjacent test fittings. At intervals during heat-cycle tests, resistance ratios and temperature rises of test fittings have been determined. Some of the tests have been continued to about 600 cycles while other tests, of small fittings, have been continued to 3,000 cycles.

Most of the tests have been made in a laboratory room so that corrosion resistance has not been an important factor.

The test results are thought to be applicable to the use of insulated aluminum cables in normal industrial service, in which conductor temperatures do not exceed 75 degrees centigrade and in which severe corrosion exposure is not a problem.

Excellent test results have been obtained with a number of types of commercially available fittings. Figure 1 shows typical fittings with which good test results have been obtained.

In general, fittings of aluminum have shown better test results than fittings of similar design but of other metals, though satisfactory test results have been obtained with some bolted fittings of tin-plated copper alloy when used on aluminum cables with strands of relatively soft temper or with a suitable joint compound or both. The generally superior performance of aluminum fittings on aluminum cable can be attributed in part to the similarity of coefficients of thermal expansion of fittings and cables.

It appears preferable for fittings, whether of compression or bolted type, to be designed for use on only one size of aluminum cable. Adequate contact area between fitting and conductor, a function of length of barrel of fitting, is important.

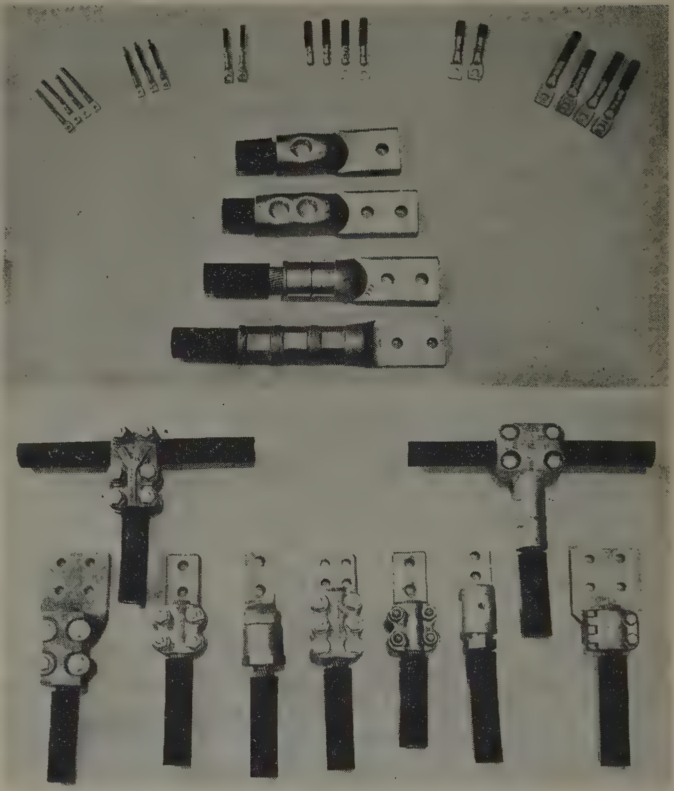
Figure 1. Typical fittings for insulated aluminum cable

Compression fittings of aluminum have shown outstandingly good results on aluminum cable. Such fittings should be of high-conductivity aluminum, *EC* grade or better, and of fully annealed temper.

It has been found that some elasticity or "spring follow-up" should be provided in the design of bolted-type fittings.

The use of a joint compound does not appear necessary in good compression fittings for low initial resistance but it is desirable to use a compound to seal the contact areas. In bolted-type fittings, the use of a suitable compound is effective in reducing resistance. In a stranded cable, it has been found that the compound preferably should be forced into the interstices between the strands.

Heat-cycle testing appears to be an effective method of testing fittings on insulated aluminum conductors, especially if differences of coefficients of expansion are involved. It appears that changes of resistance ratios have provided more sensitive indications of deterioration of connections than changes of temperature rises. It has been found that initial resistance ratios or initial temperature rises cannot be used successfully as indications of the way in which some types of fittings may perform on aluminum cable in heat-cycle tests.

Digest of paper **53-214**, "Tests of Fittings on Insulated Aluminum Cable," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Damped A-C Recorder With Quadrature Suppression

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WIDELY USED industrially to determine chemical concentration, electrolytic conductivity is measured most satisfactorily by an a-c bridge and null-type instrument, thus avoiding electrode polarization and the need for voltage regulation.[1]

Since a filled electrolytic conductivity cell may include in its equivalent circuit a series capacitance as shown in Figure 1, adjustment of R_1 cannot completely balance the bridge. The residual voltage across the detector may be called the "quadrature component."

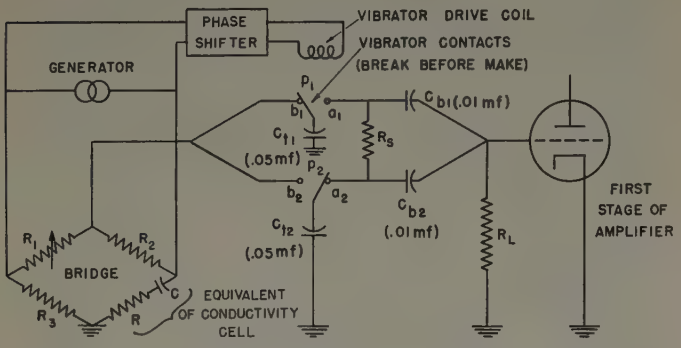

Figure 1. Simplified circuit. C_{t1} and C_{t2} sample the bridge output at the instant of contact break thus giving a single valued input to first stage of amplifier. The phase shifter is set to suppress quadrature component. C_{b1}, C_{b2}, R_S, and R_L provide damping

An electronic d-c null-type recorder produced commercially in 1933[2,3] has been simplified[4] and refined[5] but when modified for a-c measurement the quadrature component of bridge output presented a problem which was not present with recorders using an a-c galvanometer and a mechanical balancing system.[1] The circuit added between the bridge and the first stage has been found to be a solution for this problem.

The bridge output is sampled by the transfer capacitors C_{t1} and C_{t2} just when the quadrature voltage passes through zero by properly phasing the synchronous vibrator. Since the contacts p_1-b_1 and p_2-b_2 break at the positive and negative peaks of the "desired component," this component is transferred to the electronic amplifier with some enhancement. Because of this sampling technique the amplifier receives a signal which is single-valued and hence can be reduced to zero by adjustment of R_1. The amplifier's later stages (not shown) are not saturated with a useless quadrature signal which would reduce the amplifier's gain and power handling capacity, would reduce the useful power reaching the 2-phase balancing motor (not shown), and would result in a less sensitive and slower recorder.

Improved only for quadrature suppression, by leaving capacitors C_{b1} and C_{b2} and/or resistor R_S short-circuited, the a-c electronic recorder would overshoot for an abrupt change in input.

Adequate damping for the recorder is obtained when R_L is 1 megohm and R_S is 22 megohms and the capacitance values are as shown in the figure.

With R_S infinite the amplifier would contribute damping but would not have any persisting sensitivity to a persisting bridge unbalance. When C_{t1} first connects to C_{b1}, following an abrupt and persisting unbalance of the bridge, the voltage of C_{t1} is impressed upon the first stage grid. Immediately current flows through R_L developing a voltage across C_{b1} thus reducing the voltage on the grid. The same action takes place between C_{t2}, C_{b2}, and R_L. The action is cumulative since there is no way for the charge to leak off of C_{b1} or C_{b2}. As the voltages of C_{b1} and C_{b2} approach those transferred by C_{t1} and C_{t2} respectively, the a-c signal to the first grid diminishes towards zero. By reducing R_S from infinity to 22 megohms a discharge path through R_S of the capacitors C_{b1} and C_{b2} in series is provided. Even in the final or steady state they cannot be charged to the voltages on C_{t1} and C_{t2} and hence a persisting voltage with a value equal to the difference is transmitted to the first stage. In this way there is obtained an amplifier which contributes damping with persisting sensitivity and is useful therefore in balancing a null-type recorder.

Besides electrolytic conductivity there are other measurements which can be made advantageously with an a-c null-type recorder with the improved balancing amplifier. Some examples are power-line frequency measurement (by means of a bridge made up of resistors and capacitors[6]), and level, pressure, flow, and so on (by means of a differential transformer[7]).

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Oil Burner Master Heat Control

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This new stack-mounted master control for oil burners is an important development in the field of domestic heating. The circuit and components of the stack control are discussed in some detail.

FOR THE PAST 20 years, the General Electric Company has produced a line of controls for their own oil-fired furnaces and boilers. Some of these old master controls are still in operation. Size seemed to be of no importance. Steel must have been inexpensive, and labor even more so, but certainly reliability was not sacrificed. The cam-actuated Telechron motor-driven master control has proved its worth.

At the end of the second World War, a thorough analysis of the domestic heating-control field was made to determine what contributions could be made in a line of general-purpose heating controls. Functional requirements had not changed. The master control still supervised the burner and programmed its operation. Minimum life had to be 10 years. Low cost is always an important objective, along with pleasing appearance. However, the most important goals to be attained were simplicity, ease of installation, and protection from dirt and foreign matter.

With these ideas in mind the interested designers went to work and came up with four basic schemes. Those ideas then were transformed into working samples and analyzed in the light of all specifications. The choice was a thermal-timer type. It more nearly followed standard practice than any of the other schemes and was therefore more adaptable to standard units and systems interchangeability. It could be used with remote flame detection or built into the stack-switch type of control. Its inherent cost was low, and several innovations indicated that simplicity and ease of installation would be attained. The transformer and relay were combined in one device; the thermal timer was completely enclosed, and ambient compensated; the flame detector became a simple clutch-operated device divorced from all duties except flame detection.

In the schematic circuit diagram, see Figure 1, the system is shown in the ready-to-start position. The low-voltage circuit, the secondary circuit of the transformer relay, is kept open by the contacts in the thermostat. When there is a call for heat, the thermostat contacts close, thus completing the low-voltage circuit through the cold side of the flame detector, the lockout heater and contact *C*, the low-voltage contact of the ignition switch *B2*, and through the secondary of the transformer relay.

Current flowing through this circuit (and thus through the transformer relay) energizes the relay coil, which in turn closes the relay contacts *A1* and *A2*. The line-voltage contact *A1* starts the burner motor and the ignition transformer; the other relay contact *A2* closes a low-voltage holding circuit.

In addition to energizing the relay coil, the current also causes the lockout heater to begin heating its bimetallic strip. The lockout contact *C* is timed to open after $1^{1}/_{2}$ minutes of heating. If, however, flame is established before this period (which normally will be the case), the flame detector will move to the hot side. This will de-energize the lockout heater while at the same time energizing the ignition heater through the low-voltage holding circuit *A2*. After about 1 minute of current on the ignition heater, its bimetallic strip will cause both the low-voltage contact *B2* and the line-voltage contact *B1* to open. This in turn will cause the ignition transformer to be shut off.

During the remainder of the run, the ignition heater continues to be energized through the hot side of the flame detector. In case of a flame failure, the first indication is the cooling of the bimetallic helix in the stack. This opens the hot side of the flame detector, thereby opening the low-voltage circuit, de-energizing the relay coil, opening the relay contact *A1*, and thus shutting down the burner.

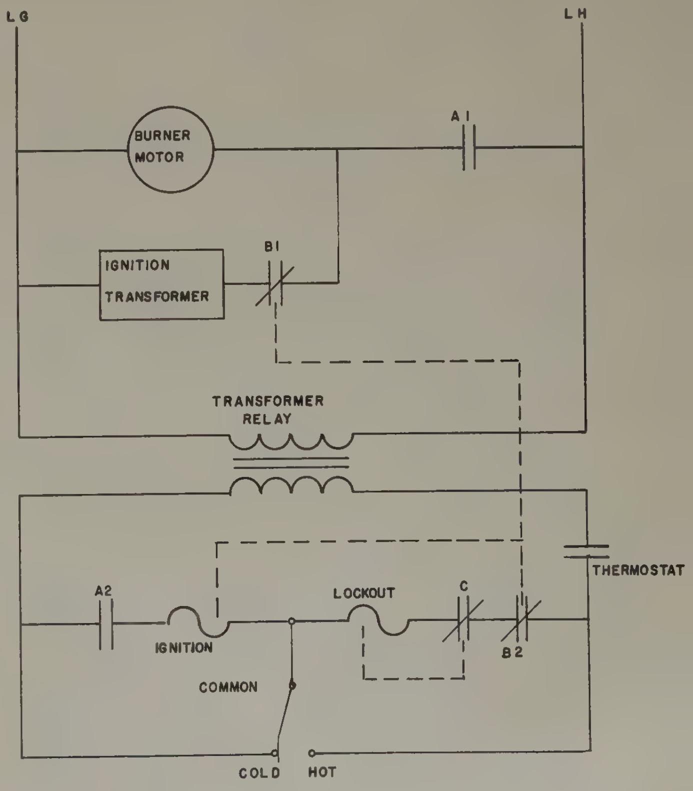

Figure 1. Schematic circuit diagram

Full text of a conference paper presented at the AIEE Conference on Domestic Appliances, Louisville, Ky., April 22–24, 1953, and recommended for publication by the AIEE Committee on Domestic and Commercial Applications.

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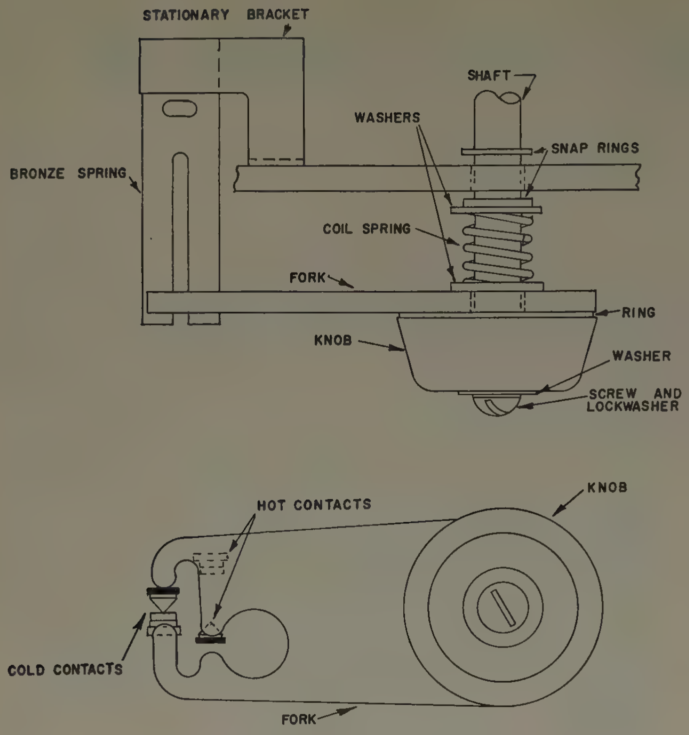


Figure 2. Flame detector assembly

The flame detector then will return to the cold side. However, before the master control can recycle, the ignition heater must cool, closing the ignition contacts *B1* and *B2*. This time lapse is called the scavenging period and allows the natural draft to clear out any oil vapors before restoring ignition.

In case of a power failure during a run, the control recycles upon the restoration of power, but not before the expiration of the scavenging period.

The master control will not start the burner unless the flame detector is on the cold side. If, after starting, the flame detector somehow should move off the cold side but fail to reach the hot side, both the lockout and ignition heaters will be energized. Each will oppose the action of the other and the burner will run with continuous ignition.

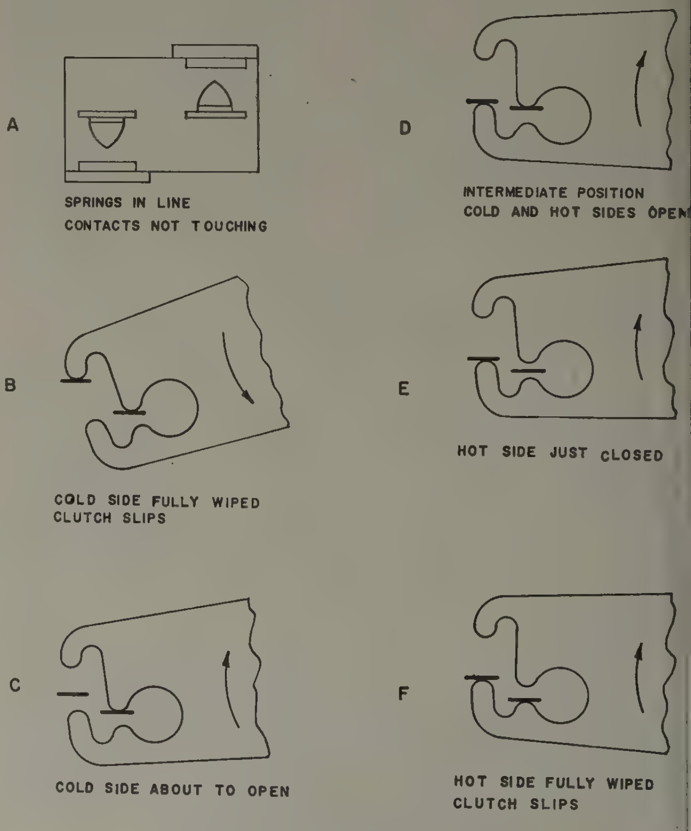
Thus in this control there is a safety shutdown only when the oil fails to ignite. On power failure or on flame failure the burner will be shut down for a scavenging period of 1 to 2 minutes. It then will attempt to start again. If normal conditions have been re-established the control will permit the burner to operate. If the burner fails to ignite, it will be shut down in lockout. It can be started again only by pressing the manual reset button after a lockout cooling period of approximately 5 minutes. This control circuit, then, permits maximum safety with a minimum number of service calls.

One of the three components of the stack control is a bimetal-actuated flame detector, see Figure 2. It does nothing but detect the presence or absence of flame. It is basically a single-pole double-throw switch with unlimited overtravel in either direction. It has a shaft which is rotated by the helical bimetal and positioned axially by two snap rings on either side of an insulating panel. A hole in the panel serves as one of two bearings. A helical coil spring compressed between two washers provides a load against a fork made of Textolite insulating material. This fork presses against a burnished brass ring. The end of the shaft is knurled to mate with the positioning knob, and the screw and lock-washer attach this knob securely to the shaft. The fork is permanently lubricated by tumbling in moly-sulphide and is held in any one position by friction. There is no adjustment required on the clutch assembly.

The single-pole double-throw contact assembly was designed to eliminate the need for a shunt. It provides independently variable hot and cold side wipe to take care of variations of ambient temperature in the absence of flame and stack temperature variations as the flame fluctuates slightly.

The movable contact assembly consists of a flat bronze spring on which are welded two contacts. The spring is slotted down the middle, somewhat shorter than the length of the strip, and welded to a stationary bracket to form a simple cantilever. The two fingers formed by slotting the spring are normally in line in their free position, with the contacts open. Since these two fingers are not completely separated, any deflection of one of the fingers produces a somewhat lesser deflection, or bias, on the other. This dual contact device is thus made self-biasing by offsetting the actuating fingers of the clutch fork. This bias of the contact fingers is in a direction toward their contact engaging position, thus maintaining positive contact pressures. Figure 3*A* shows the free position of the contact springs before the fork is assembled to provide the bias.

Contact wipe is predetermined by the distance between



SPRINGS IN LINE
CONTACTS NOT TOUCHING

COLD SIDE FULLY WIPED
CLUTCH SLIPS

COLD SIDE ABOUT TO OPEN

INTERMEDIATE POSITION
COLD AND HOT SIDES OPEN

HOT SIDE JUST CLOSED

HOT SIDE FULLY WIPED
CLUTCH SLIPS

Figure 3. Flame detector operation

the fingers of the fork. Figure 3*B* shows normal operation with the cold side fully wiped. Continued rotation of the shaft will cause the clutch to slip. In Figure 3*C* the rotation of the shaft has reversed upon heating of the bimetallic helix, and most of the cold side wipe has been lost. The movement of the left contact finger across the gap in the fork is a visual indication of this wipe. At this point the cold side is about to open.

In Figure 3*D* the flame detector is midway between the hot and cold contacts. In Figure 3*E* the right-hand spring has just left its upper stop on the fork, indicating that the hot side contact has just closed. Finally in Figure 3*F* the hot side is fully wiped and further rotation causes the clutch to slip. The reverse of this action takes place on cooling of the bimetallic helix.

The second device in this stack control, see Figure 4, is a transformer relay designed to save space, material, and weight by combining a transformer and relay into a single unit. Both the transformer and relay are conventional in function, but each has parts in common with the other. In this unit the primary corresponds to the standard transformer primary, but the secondary winding serves both as the transformer secondary and as the relay coil. The center leg of the magnet frame serves as part of the transformer magnetic circuit as well as part of the relay magnetic circuit.

In operation the primary is connected to a source of a-c power, and a magnetic flux is generated, most of which follows the path of the arrows in Figure 4. However, when the secondary coil circuit is closed, the current induced in this secondary coil produces a flux which tends to oppose the magnetic flux of the primary. As a result of this, less primary flux passes through the center leg and instead passes up through the armature and the outside leg. This causes the armature to pull in and close its contacts. Its operation is that simple. However, a 40-page mathematical analysis of the transformer relay is beyond the limits of this article.

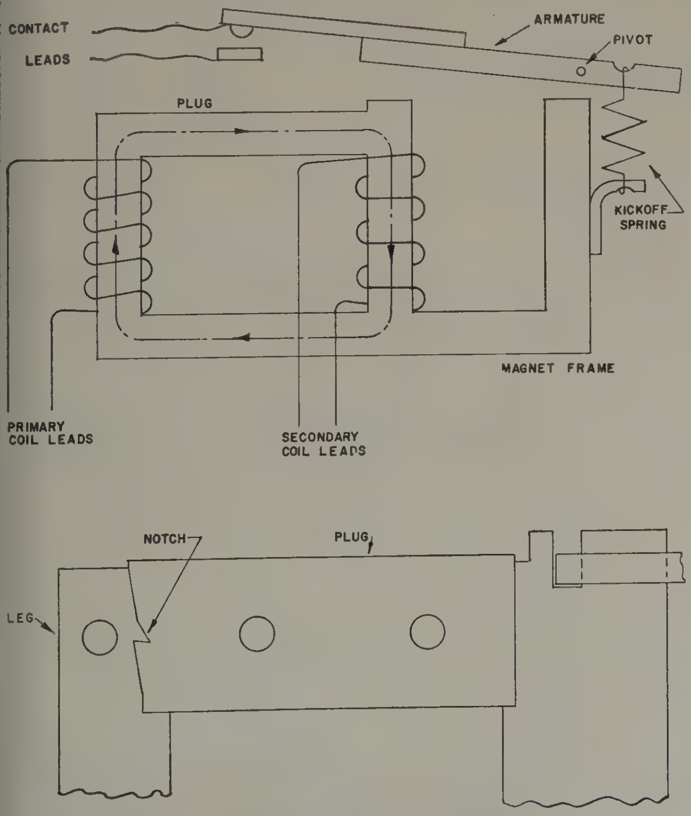


Figure 4. Schematic diagram of transformer relay

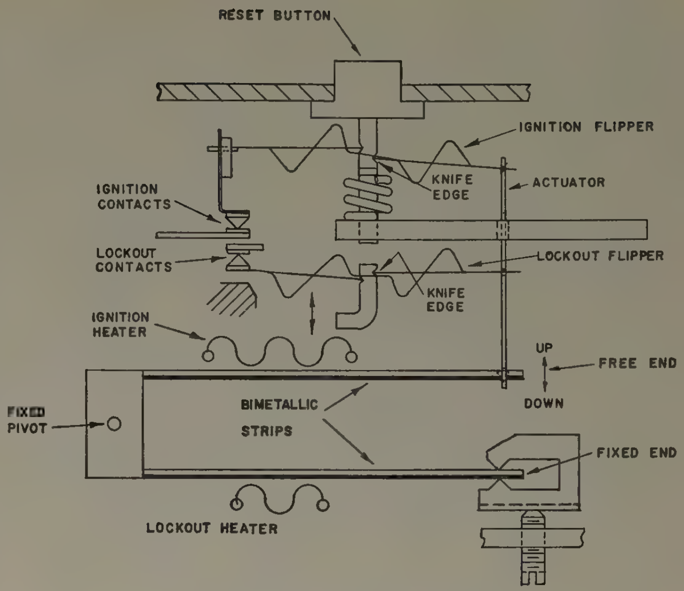


Figure 5. Thermal timer

Just one point about the construction of the magnetic circuit. Each lamination is punched in one die operation, producing two pieces, with almost perfect mating after stacking and riveting. The coils are slipped on the two legs and the plug is pressed into place. A projection on the leg snaps into a mating notch in the plug, producing a tight mechanical connection with no air gap. To replace a coil this plug must be slid out sideways. This, in brief, is the combination transformer relay.

The third and last part of the stack control is the thermal timer. It is the device which provides ignition timing, purging or scavenging period, lockout timing, and a lockout reset period; see Figure 5.

The action of the timer is provided by two bimetallic strips upon which are wound separate heaters. These two bimetals are punched as one piece, then separated and paired to eliminate tolerance build-up. They are attached to a common support which is free to pivot about a fixed shaft. Lateral motion of the lockout bimetal is restrained at one end. Consequently, on heating, its curvature produces a deflection in the downward direction to trip the lockout switch. Heating of the ignition bimetal moves the common actuator upward to open the ignition contacts. Equal heating of both bimetals produces no net movement of the actuator. The ambient compensation is such that the ignition timing period is only changed about ten per cent at 65 degrees Fahrenheit below zero. This change is deliberately added by making the lockout bimetallic strip slightly longer than the ignition bimetal. As ambient temperature rises the transformer relay coil resistance increases and its current output decreases. Mismatching the bimetal lengths serves to produce a slight motion of the actuator in the lockout direction with this increased ambient. Thus the lockout timing is substantially constant over a considerable range of ambient temperature.

Scavenging period is incorporated in the time required for the ignition bimetal to cool sufficiently to reset the contacts automatically. The lockout contact assembly is so arranged that even after cooling of the lockout heater the contacts will not reset automatically. The manual reset button must be pressed. This not only resets the lockout switch but also opens the ignition switch, thereby effectively preventing anyone from defeating the purpose of the safety lockout by blocking in the reset button.

The ignition heater consists of glass-covered Nichrome wire wound around a preformed strip of high-temperature Teflon, in relatively close thermal contact with the bimetallic strip, and distributed along a considerable portion of the length of the strip. This recycling heater thus is arranged for a relatively quick thermal response. The lockout heater is arranged for a relatively slow response by wrapping the glass-covered Nichrome wire on a cylindrical sleeve of silicone rubber concentrated over a short length of the bimetallic strip.

A common actuator operates the ignition flipper in one direction and the lockout flipper in the other. These wiggly flippers, or "grasshoppers," are accurately preformed strips of beryllium copper, pivoting about the coined knife edges of the center legs. These knife edges pivot in offset grooves made in a brass punching. This small offset in the punching causes the actuator end of the flipper to go to zero force while still maintaining contact pressure. At this point the actuator end of the flipper snaps rapidly across a slot in the actuator, causing the tip pressure to pass rapidly through zero and snap open to its stop. No adjustment is required for proper tip pressure, wipe, or gap.

All timing is preadjusted at the factory with two adjustments. The fixed end of the lockout bimetal is positioned to obtain the exact force to trip the ignition flipper, and the lockout pivot is positioned to obtain an exact force to trip the lockout flipper. This is done with the use of dead weights and frictionless pivots in the adjusting fixture. All timing on each control is checked on an automatic timing panel.

Ten years ago this heating control could not have been produced. Teflon, silicone rubber, beryllium copper, and moly-sulphide are some of the newer materials which did not exist or were not in common usage 10 years ago. These new materials, along with modern equipment and processes, are keeping a great industry devoted to progress in human comfort in step with the times.

Modern Electric Distribution System for an Oil Refinery

V. L. NEALY

TWO PRIME CONSIDERATIONS in any refinery electric system should be flexibility and dependability. These factors entered markedly into the selection and design of the distribution system which consists of a primary selective combined with a secondary selective system, see Figure 1. The common secondary tie is an aerial loop which is sectionalized by means of pole-mounted switches, normally open. The loop serves the twofold purpose of a secondary tie, when needed, as well as a wide-area distribution feeder covering several miles with numerous loads tapped off, somewhat on the order of a public utility system serving a populated area. The other secondary feeders out of the substations are underground cables direct to points of usage.

The choice of a distribution system was based primarily on reliability, with flexibility, simplicity, and cost as additional considerations. The nature of refinery processes is such that the various operating units are required to run continuously for as much as 6 months or a year. A power outage of long duration may cause an emergency shutdown of one or more units which can be both hazardous and costly.

The extent of the plant is such that a secondary aerial loop feeder was practically the only choice, so it was only logical to choose a secondary selective system with the loop feeder serving as a tie cable between substations in the event of an outage at any station.

A secondary network system might have been used in lieu of the secondary selective chosen, but the increased reliability is so small in comparison with the increase in complications that it hardly could be justified. In fact, with the long exposed secondary aerial loop, it is questionable whether the network system would be any more reliable than the selective. Coupled with this argument

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A general description of the electrical facilities, designed and installed at a plant which began operating less than 5 years ago, is presented. This plant was designed and built as a complete unit, but with allowance in the various utilities for possible future expansion. A brief description of certain features of the distribution system including relay protection and the use of aerial cable also is included.

s the fact that two primary feeders serve each station, and unless a bus fault should occur at a station, almost any fault may be taken care of by proper switching, on the primary or secondary side.

All electric power is normally generated at the plant by means of steam turbogenerators, with a stand-by connection to the public utility system. Generation and primary distribution are at 13.8 kv, with a metal-clad back-to-back double-bus switchgear at the power plant serving as the primary distributing point. The public utility stand-by connection mainly is intended to be used in emergencies, but also may be used to augment the plant's generating capacity if required. The generators are Y-connected with the neutral grounded through a resistor.

Control of the generators and 13.8-kv switchgear is centered in a duplex unit having instruments, metering, and the various manual devices on the front panel, with all protective relays located on the rear panel.

The relaying is conventional for the most part with the exception of a reverse-power relay on the stand-by connection. It must be sensitive enough to operate on magnetizing current for the transformer tie between the public utility's 26.4-kv line and the plant's 13.8-kv system. This is necessary when operating in parallel with the public utility since an outage on their line followed by restoration of power might have disastrous results if prior tripping of the tie breaker had not occurred.

Power factor adjustment of this relay is also quite critical since it must discriminate between a dead line and the condition wherein normal power is flowing toward the plant with reactive power being carried by the public utility. Such a condition arises due to voltage fluctuations in the utility's system with a consequent shift of reactive power to or from the plant. The over-all plant power factor averages about 93 per cent so that the reactive power is ordinarily small in any case. Voltage regulation is also good, and this is due in part to the extra capacity provided throughout to take care of emergency conditions as well as future expansion.

As mentioned previously and as indicated on Figure 1, the 13.8-kv switchgear distributes all power generated or purchased including station service which is fed to transformers and 2.4-kv switchgear at the power plant for auxiliaries. Each plant substation is served by two primary feeders with the two single-ended substations fed by two primary cables in common, and the one double-ended station by two other feeders independently. Normal line-up is such that each of the four 13.8-kv feeders is serving only one single-ended station or one-half of the double-ended station at a time, although each feeder has ample capacity to carry two single or one double station if required.

Each primary feeder as well as the tie feeder from the public utility line consists of three rubber-insulated and shielded single conductors plus a supporting messenger to form a preassembled aerial cable rated at 15 kv grounded neutral. The aerial cables are supported on steel poles and steel towers from the power plant to the various substations where they terminate at the selector switches.

Some difficulties have been encountered with the aerial cable due apparently to ionization or corona cutting. Unfortunately when a fault does occur, the evidence is usually destroyed, but examination of numerous random samples has established fairly well that ionization was responsible. However since that time it has been announced that ionization-level tests now are being made by the factory on all new cables of this class, and that such tests are the basis of accepting or rejecting a length of cable. While these tests do not pin-point the defect or defects, they do indicate whether or not such defects exist.

The installation of aerial cable for primary feeders at this plant is the first such installation in this company, and the decision to use it was based on appearance, space requirements, and possible future expansion. The installation of several open-wire aerial feeders certainly would have been both unsightly and cumbersome. Underground cables were considered, but were ruled out finally for several reasons, one of which was the ease of extending or adding to the present feeders. Despite the afore-mentioned difficulties due to ionization, the use of aerial cables for primary distribution seems to have been justified.

The choice of 13.8 kv for generation and primary distribution was based largely on the anticipated ultimate capacity of the plant rather than on the initial installation in order to avoid changeover at some future date from a lower to a higher primary voltage. Present loads probably would have made either 2.4 kv or 4.16 kv the most economical voltage.

The two single-ended and one double-ended plant substations are all identical in component parts including transformer capacity. Each station is equipped with a transformer primary selector switch interlocked with the secondary main circuit breaker to insure no-load switching of the primary feeders. The main secondary bus supplies three outgoing secondary feeders from each single-ended station and from each half of the double-ended station. The latter is equipped with an automatic bus-tie breaker which closes on voltage failure of either bus.

As mentioned previously, one secondary feeder from each station serves as an aerial distribution feeder and as a bus tie between stations through normally open sectionalizing switches. This aerial loop feeder is of conventional open-wire cross-arm construction. The other substation feeders are underground direct to load centers.

Secondary voltage is 2.4 kv, delta, ungrounded, which raises the controversial subject of grounded versus ungrounded systems. The choice of ungrounded in most of this company's plants is based on the nature of refinery

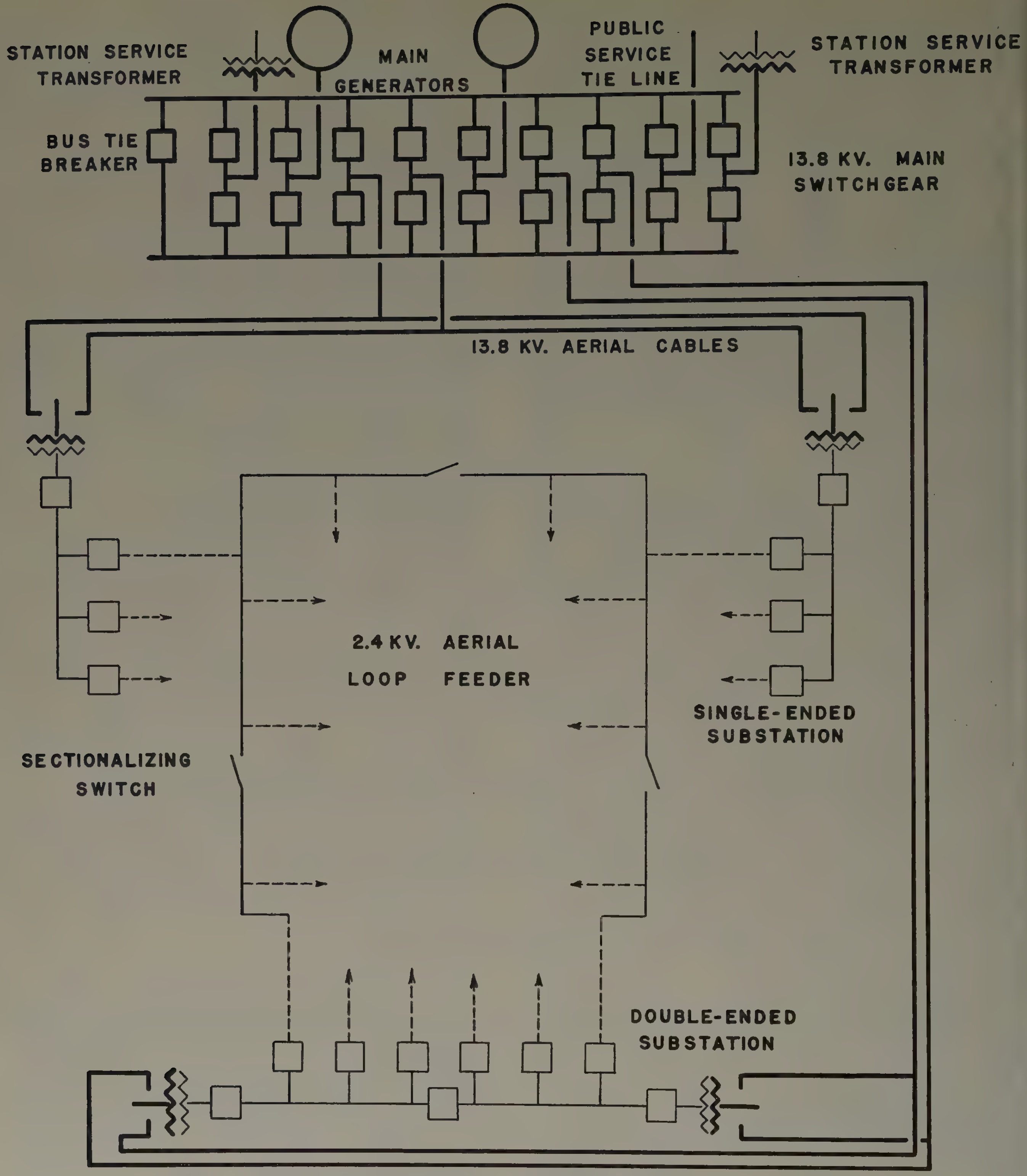

Figure 1. Simplified 1-line diagram of 13.8- and 2.4-kv distribution systems

operations which are not stopped or started readily. For this reason it is highly desirable to maintain continuity of service. With a grounded system, a phase-to-ground fault will trip out the feeder immediately; with an ungrounded system, a phase-to-ground fault usually will permit continued operation of the system. Ground detectors are to be installed at each substation to indicate the existence, if not the location, of a ground. It is realized that there are numerous objections to an ungrounded system, and no attempt will be made to argue these differences here since it is felt that each industry can determine the best system for its needs.

Those secondary feeders at this plant which run underground are nonmetallic sheathed, neoprene-jacketed, rubber-insulated conductors in metallic conduit encased in concrete. This same design is used for nearly all underground electrical services in the plant with exception of a few low-voltage power and control circuits which utilize direct-burial parkway cable.

The use of nonleaded conductors eliminates the necessity for pothead terminations which are costly and time-consuming to install, as well as troublesome if removal becomes necessary. Experience over a period of 4 years at this plant and at least 10 years at other plants in the company has indicated that nonleaded cables are quite satisfactory and much easier to handle; they are also less likely to be damaged at the time of installation.

Although the neoprene-base jackets are designated as oil-resistant, they are not guaranteed to withstand continuous immersion in oil, which may raise some objection to their use. However, this never has proved objectionable in our experience since the conductors are pulled into metallic conduits. Moisture due to condensation in the conduits is no problem since this type of insulation is completely waterproof.

It also might be noted that the 13.8-kv primary underground services from the aerial cables to the substations are similar to the other underground cables with the exception of having a grounded shielding tape to dissipate the charge which otherwise would accumulate and attack the insulation. These conductors also are installed in metallic conduit.

In addition to the 13.8-kv primary and 2.4-kv secondary systems there are three other principal electric systems in the plant:

1. Low-voltage power.
2. Low-voltage lighting.
3. Constant-current, series street lighting.

The low-voltage power is at 480 volts, delta, ungrounded, and is derived from the 2.4-kv feeders by means of 3-phase transformers. This power is fed either directly to load centers or to aerial feeders for distribution to several points. As a general rule, motors of 100 horsepower and below are at 480 volts while those above 100 horsepower are wound for 2,400 volts.

All motors in the plant, large and small alike, are full-voltage start. However, the majority of the motors are driving centrifugal pumps which impose very little starting load, so that the shock to the system is relatively light and of short duration. Control of the smaller motors is by combination circuit breakers with magnetic starters. The larger motors are controlled by electrically operated circuit breakers.

Lighting service for all purposes other than street lighting is at 208/120 volts, 3 phase, 4 wire, grounded neutral, from 3-phase transformers operated off the 2.4-kv feeders.

Series street lighting is supplied by constant-current transformers, utilizing both aerial and underground series circuits. Small series lighting transformers are used at the fixtures to maintain continuity of service in the event a lamp burns out. All series lighting circuits are turned on and off automatically by photoelectric cells.

No mention has been made so far of the type of motor and starter enclosures used to meet the varying degree of hazardous atmospheres encountered throughout a refinery. Like many points for discussion this too is somewhat controversial in the industry. The Fire Underwriter's designation for hazardous areas containing petroleum vapors is Class *I*, Group *D*, and approved equipment for such areas is commonly known as "explosion-proof" equipment.

The question often arises in borderline cases whether or not the use of explosion-proof equipment is justified. Our general policy is to use explosion-proof equipment, including motors, starters, lighting fixtures, and switches, around operating units, particularly in enclosed pump rooms where petroleum vapors might accumulate. Explosion-proof equipment is in general weatherproof, and as such often is used outdoors without shelter even though no particular hazard exists.

One other subject to be touched upon which particularly affects any plant with long exposed aerial feeders is that of lightning protection. Our primary 13.8-kv aerial cables are felt to be comparatively immune from lightning by virtue of their construction and installation. The shielding tape, supporting messenger, and copper binding strip are all well grounded at numerous points. Also, an overhead guy between the supporting steel poles provides a zone of protection. As a further precaution, the main generators are protected by means of surge capacitors and arresters at their terminals.

The exposed 2.4-kv aerial feeders on wooden poles are considerably more vulnerable to lightning than are the aerial cables. To protect these feeders lightning arresters are installed at numerous locations, including all service taps, dead-ends, sectionalizing switches, and junction points. Such arresters are only effective if their grounding is adequate, and every effort has been made to provide low-resistance grounds in the order of 5 ohms or less.

Finally, a word about interrupting capacity and relaying. A short-circuit study was made initially for the plant electric system, and all relay settings were co-ordinated to provide selective tripping of the breaker nearest a fault. Interrupting capacity of all breakers is considerably in excess of the calculated 3-phase, symmetrical, short-circuit kilovolt-amperes that could be developed.

Miniature D-C Motor

A miniature d-c motor is being produced by the General Electric Company for use in defense systems of the most advanced operational bombers. About the size of an ordinary ink bottle, $1^1/_5$ inches in diameter, $2^3/_8$ inches long, the motor weighs approximately 8 ounces. Rated at 0.002 horsepower at a speed of 6,500 rpm, it is so sensitive that it is controlled by the output of two small vacuum tubes.

Of the split-shunt reversible-rotation type, drawing maximum armature currents of 0.8 ampere from a 28-volt line, the motor is required to withstand a high potential of 1,500 volts above the ground. It is capable of responding to field currents of 0.00075 ampere and is unaffected by dry, hot, or humid environmental conditions.

Generator Protection from Unbalanced Currents

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WHEN A GENERATOR is subjected to unbalanced short-circuit currents, a negative-sequence current (I_2) is caused to flow in the stator windings, establishing a counter rotating flux that induces double-frequency rotor currents. The rotor currents flow in the surface parts of the rotor and cause detrimental heating. The generator is susceptible to varying degrees of damage depending on the magnitude of the negative-sequence current.

It has been shown that the power loss in the rotor during unbalanced faults and hence the heating of the rotor are closely proportional to the integrated product i_2^2t where i_2 is the instantaneous value of negative-sequence current as a function of time, and t is the time in seconds. For a given function of i_2 and a given interval of time, an equivalent negative-sequence current (I_{2eq}) can be determined, which is actually an rms value and produces the same heating effect as the actual i_2 that decays with time. Thus, the rotor heating is proportional to H, where $H = I_{2eq}^2t$.

The new standard on short-circuit requirements for synchronous machines proposed by the Committee on Rotating Electric Machinery bases the permissible short-circuit time under unbalanced fault conditions on a constant value of I_{2eq}^2t. The established limits are I_{2eq}^2 equal to 30 for turbine generators, synchronous condensers, and frequency changers, and I_{2eq}^2t equal to 40 for water-wheel generators and engine-driven generators.

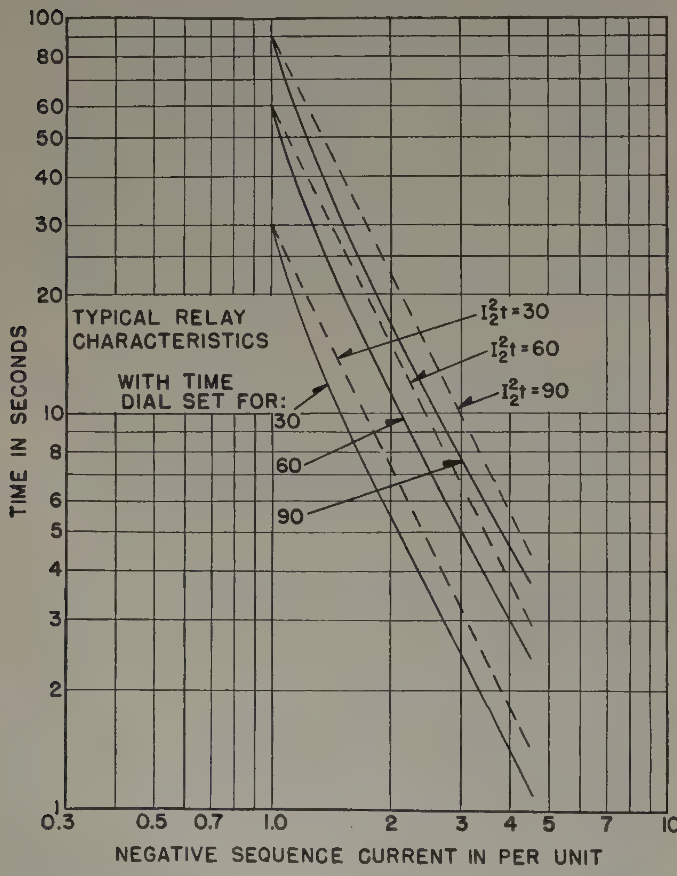

Figure 1. Time–current characteristics of the generator negative-sequence current relay compared with curves of I_{2eq}^2t = a constant, for three settings of the relay

This method of stating the short-circuit requirements for synchronous machines enables the user to take into account the effects of a generator voltage regulator and a connected system. It also means that a relay can be applied to protect the generator from damage of any kind provided the relay meets the established heating criterion.

A relay to provide such protection should match the solid-line curves of Figure 1 at least to a time of 30 seconds to provide some margin with respect to the dashed-line curves of I_{2eq}^2t = a constant. If the relay trips in times shorter than those permitted by the standard, the generator is apt to trip unnecessarily and before the full capacity has been used. A relay requiring a longer time to trip would jeopardize the machine and there would be doubt as to whether a rotor inspection should be made.

Since negative-sequence current is one of the terms of the limiting equation, any relay design, to provide the desired protection, must contain a network of impedances with an output proportional to the negative-sequence input. The output of this network or filter can be used to energize a relay element of the induction-disk type and this simple combination of elements provides an operating characteristic that can be co-ordinated with the generator characteristic as shown in Figure 1. Since the minimum permissible generator characteristics of I_{2eq}^2t are 30 and 40 and there is a possibility in some instances that the relay might be set for higher values, the relay characteristic is adjustable from 30 to 90.

In applying the generator negative-sequence current relay, it is only necessary to select a tap corresponding to one per unit generator current in terms of the current transformer secondary amperes, and a time dial setting representing the chosen value of I_{2eq}^2t.

The relay is designed to match closely the curves of I_{2eq}^2t set forth in the new standard for magnitudes of I_{2e} equal to or greater than one per unit. For smaller magnitudes of negative-sequence current, the permissible time is somewhat longer than indicated by the limits in the standard, and the relay is designed to allow appropriately longer times before tripping. The relay properly applied can be used to protect the machine against prolonged negative-sequence current and remove the machine from the system before it is subjected to possible damage.

Digest of paper 53-52, "Protection of Generators Against Unbalanced Currents," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Instability of Self-Saturating Magnetic Amplifiers

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ACCORDING TO THE simple approximate theory for self-saturating magnetic amplifiers, a plot of output versus control current for these amplifiers has the shape of the left-hand portion of the hysteresis loop of the core material. Maximum amplification thus calls for the use of a core material having a rectangular hysteresis loop.

The use of rectangular loop core material increases the gain but gives rise to an unanticipated operating instability sometimes referred to as triggering. The load current can be decreased continuously from its maximum to its minimum value. When the load current is increased from its minimum value, however, it changes discontinuously or triggers from a small to a large value (Figure 1).

To study the role of the core material in this phenomenon, representative cores were subjected to d-c magnetic measurements while being cycled in a manner similar to that occurring in a self-saturating magnetic amplifier. Measurements of this type made on a Hipernik V core are plotted in Figure 2. The increase in magnetization during the positive half-cycle of supply voltage is given by

$$(\Delta\Phi)^{+}=\frac{1}{N}\int_{0}^{T/2}(e-iR)dt$$

During the negative half-cycle the decrease $(\Delta\Phi)^{-}$ is limited by the fact that due to the presence of the rectifier the flux does not fall below the value corresponding to the control bias. If $(\Delta\Phi)^{+}$ exceeds $(\Delta\Phi)^{-}$ in each cycle, the operating loop will ratchet into positive saturation as shown in Figure 2. The figure also shows that after reaching positive saturation, $(\Delta\Phi)^{-}$ is less than during upward ratcheting. As a result less volt-seconds can be absorbed inductively in the forward half-cycle, and the difference shows up in load current which appears suddenly at the end of ratcheting, thus accounting for the discontinuity in Figure 1.

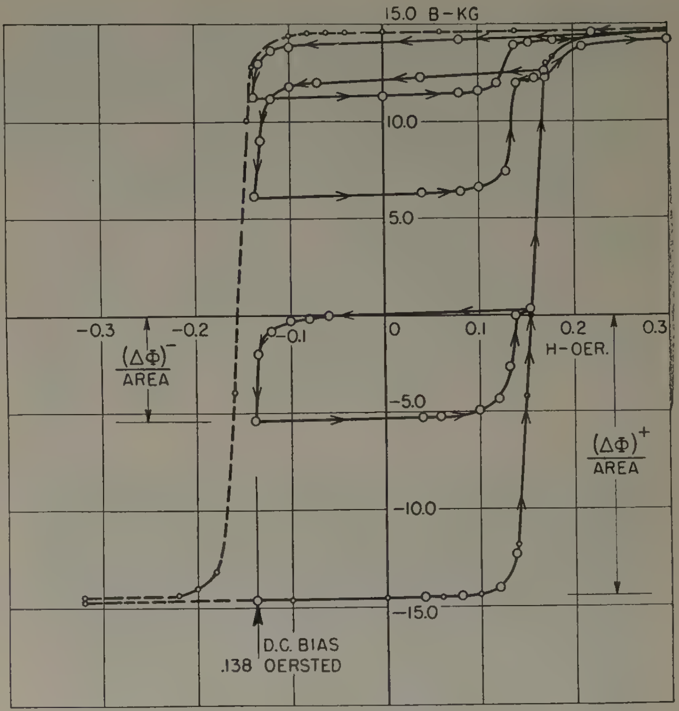

Figure 2. D-c triggering of Hipernik V magnetic amplifier core 3/4 inch by 1 inch by 1/4 inch

It is evident from the experimental data (Figure 2) that in Hipernik V there are certain differences between major and minor loops which are of importance in the triggering problem. The tops and bottoms of all loops are substantially horizontal; the sides have a common slope slightly inclined to the vertical; the upper left-hand corners of all minor loops are approximately on a vertical line, and the lower right-hand corners are on another. These characteristics are accounted for in terms of a simple phenomenological theory. This theory assumes the material consists of a large number of domains, that each domain flips from antiparallel into parallel alignment with the magnetic field at a definite value of field strength called the coercive force, and that there is a small spread in coercive forces. The fact that $(\Delta\Phi)^{-}$ is smaller after reaching saturation follows from the fact that the upper left-hand corner on the major loop lies a little outside the vertical line through the corners of the minor loops. This may be a nucleation phenomenon.

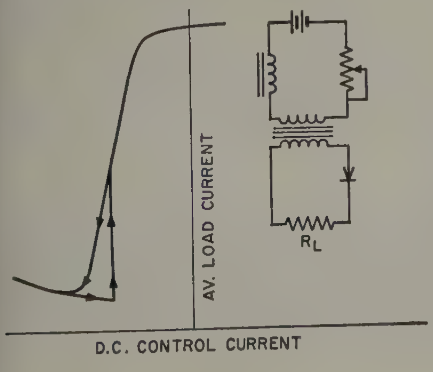

Figure 1. Control characteristic for a half-wave self-saturating magnetic amplifier

A nontriggering core also was investigated. The hysteresis loop of this core had less steep sides and more rounded corners. The operating loop did not have the ratcheting characteristics shown in Figure 2 because $(\Delta\Phi)^{-}$ kept increasing as the operating loop rose.

The foregoing statements apply in the case of a magnetic amplifier with ideal circuit elements. The modifications resulting from rectifier leakage, eddy currents, and so forth, are not considered in this article.

Digest of paper 53-18, "An Instability of Self-Saturating Magnetic Amplifiers Using Rectangular Loop-Core Materials," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Ice Melting on a Power Line While in Service

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ONE OF THE most serious problems that confronts a system operator is the effects of a dreaded ice storm. Angular displacement of the voltages applied to the extremities of a power line for the purpose of circulating sufficient current to heat the conductors will assist in solving this problem. When this displacement does not exceed 60 degrees, reasonable service for all customers supplied by the line ordinarily can be maintained while the ice is being melted. The method holds a great deal of promise for those long, lightly loaded lines in the moderate- and low-voltage class which so often fall prey to these storms. By choice of line length this circulating current plus load current can be made sufficient either to melt the ice or prevent its formation. The driving voltage E_c which produces the circulating current, varies with the angle between the normal and the displaced source. For a given driving voltage the circulating current I_c is determined by the impedance of the circulating current path, and the angle between E_c and I_c is determined by the circuit characteristics of this path.

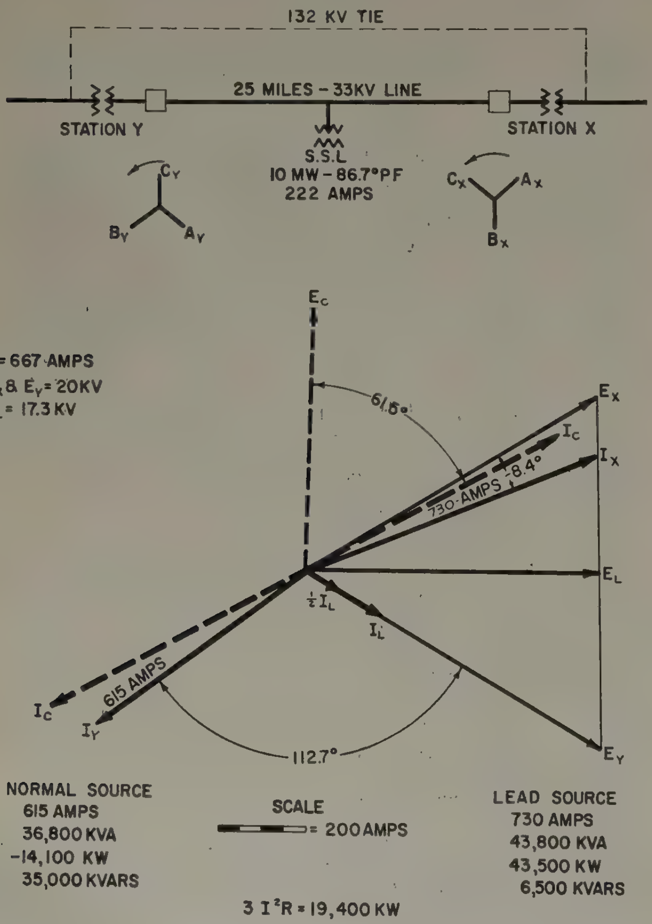

Figure 1. Load conditions at both ends of a power line displaced 60 degrees with one load taken off at the mid-point

A 60-degree displacement between sources can be obtained by the use of selective disconnects installed for the purpose of reversing the polarity of individual transformers and rotating the phase connections to the line. E_c in this case will be equal to the phase-to-neutral voltage of the supply source.

The upper part of Figure 1 represents a 33-kv transmission line between station *X* and station *Y*. Station *X* leads station *Y* by 60 degrees. If the total impedance of the circulating current path is 30 ohms and assuming a phase-to-neutral voltage of 20 kv, the circulating current becomes 667 amperes per phase. Both station *X* and station *Y* must have a firm supply electrically connected by other parallel ties to assure phase relationship and to complete the path for the circulating current. A load of 10,000 kw at 86.7-per-cent power factor is connected at the electrical mid-point. The total current at the leading source will be 730 amperes and 615 amperes at the normal source. The lower part of Figure 1 shows the vector relationship and load at each station. It will be noted that the total current at the leading station is nearly in phase with the voltage E_x and therefore mostly real power. The current at the normal station lags the voltage E_y by a large angle, indicating that this source supplies most of the reactive requirements. Since this angle is more than 90 degrees, the kilowatts supplied from the leading source not used for the load and for heating the conductor (I^2R) will be transmitted to the normal source. It is important that the lagging source have sufficient Var capacity and control to maintain satisfactory voltage to the customers.

The same principle can be applied to a group of transmission lines. The current may not be enough to melt the ice on all the lines, but if put in effect during the storm, the heating effect may be sufficient to prevent ice formation on the conductors. The more lines that can be loaded, the greater are the possibilities for a system to withstand a severe ice storm.

The system operator must have a clear picture of the problems involved in order to apply intelligently the phase-shift method of ice melting. He must provide adequate kilowatt and kilovar capacity at the points where needed. He must know his line and station equipment limitations. He must arrange his system for varying conditions such as storm location and line availability, being always mindful of his prime responsibility—that of keeping the power flowing.

Digest of paper 53-380, "A System Operator's View of Ice Melting on a Power Line While in Service," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Field Testing 400-Kv Circuit Breakers

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In the Swedish 400-kv network, three types—two air-blast and one oil-minimum—of circuit breakers have been tested with regard to switching overvoltages. The method of measurement and the results obtained are discussed here.

THE INSULATION level of the Swedish 400-kv system, which has been in service since March 1952, primarily was determined with regard to the internal overvoltages. The cases on which the determination was based comprised combinations of overvoltages at the service frequency, set up on disconnecting the load on long transmission lines and switching overvoltages. The former mainly were determined theoretically, whereas in order to obtain a knowledge of the latter it was necessary to carry out tests in the network.

For the purpose of providing data for the designing of the 400-kv circuit breakers, tests were undertaken with 220-kv breakers[1, 2] in which attempts were made to reproduce the conditions existing in the 400-kv network as closely as possible. On the basis of the results obtained, it was considered that the demand might be made in the contract for the 400-kv circuit breakers that the latter should not have a higher overvoltage factor than 2.5 for certain specified cases of circuit interruption. The overvoltage factor was defined as the ratio of the peak value for the recovery voltage to ground and the amplitude value of the phase voltage prior to interruption. This demand was to be met in the following cases:

1. Interruption of an unloaded transmission line 310 miles (500 kilometers) in length at a voltage of 600 kv.
2. Interruption of an unloaded 300,000-kva transformer at 420 kv.
3. Interruption of a transformer loaded with reactors having ratings between 40,000 and 180,000 kva at 420 kv.

Hitherto, 32 circuit breakers had been purchased from five different firms for the 400-kv system. Of these, 26 are air-blast circuit breakers of three different types and six are oil-minimum circuit breakers of two types. Three of the types of circuit breakers were delivered in the course of 1952, and field tests were carried out with these in the Swedish network during October and November of the same year.

CIRCUIT BREAKERS USED FOR THE TEST

THE THREE following circuit breakers have been tested:

ASEA (Allmänna Svenska Elektriska Aktiebolaget) circuit breaker having the type designation *HTFYC 380/1009*. It is a circuit breaker with nine breaking elements, rated pressure 220.5 pounds per square inch (15 atmospheres), minimum pressure for interruption 176.4 pounds per square inch (12 atmospheres). The circuit breaker is equipped with nonlinear resistors connected in parallel across each breaker pole. The resistor current is interrupted by means of the breaker's forcibly operated series-connected isolating switch. The circuit breaker has a current rating of 1,000 amperes and a guaranteed symmetrical breaking-capacity of 8,000,000 kva at 350 kv. Figure 1 shows the circuit breaker.

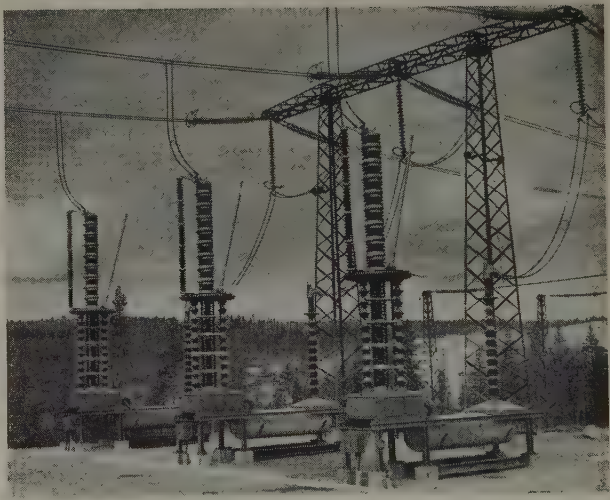

Figure 1. ASEA HTFYC 380/1009 400-kv air-blast circuit breaker

Brown-Boveri circuit breaker having the type designation *DCVF 400 m 7500*. It is an air-blast circuit breaker with ten power breaks, rated pressure 220.5 pounds per square inch (15 atmospheres), minimum pressure for interruption 176.4 pounds per square inch (12 atmospheres). The circuit breaker is equipped with nonlinear resistors having relatively high resistance across each power break. The resistor current is interrupted by means of a special break per element. A series-connected isolating switch is omitted. The circuit breaker has a current rating of 1,000 amperes and a guaranteed symmetrical breaking capacity of 7,500,000 kva at 350 kv. Figure 2 shows the circuit breaker.

Sprecher and Schuh–Delle circuit breaker "Orthojecteur" type having the designation *HPF 316*. It is an oil minimum circuit breaker with two rupturing chambers per pole. Nonlinear resistors and isolating switches are not employed. The circuit breaker has a current rating of 1,000 amperes and a guaranteed symmetrical breaking capacity of

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A special article recommended for publication by the AIEE Committee on Switchgear.

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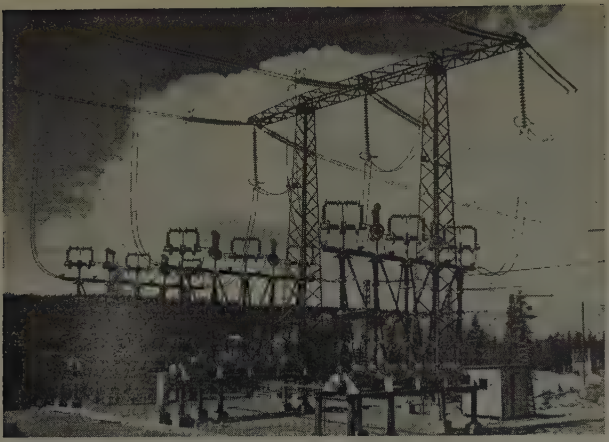

Figure 2. Brown Boveri DCVF 400 m 7500 400-kv air blast breaker

7,500,000 kva at 350 kv.* Figure 3 shows the Sprecher and Schuh circuit breaker erected for testing.

The afore-mentioned breaking capacities for the circuit breakers are defined in accordance with the Swedish Standards. According to these, the circuit breakers should be tested at a recovery voltage which is at least 15 per cent higher than that adopted for calculating the foregoing symmetrical breaking capacities at the rated breaking current.

TYPES OF TESTS

THE INVESTIGATIONS were comprised of the following types of tests:

A. Interruption of an unloaded transmission line (corresponding to case 1).

B. Interruption of a transmission line with a reactor-loaded or unloaded transformer connected at the far end.

C. Interruption of a reactor-loaded or unloaded transformer (corresponding to cases 2 and 3).

THE TESTING SYSTEM

THE TESTS WERE carried out with the test circuit breakers installed at Harsprånget. For the interruption of an unloaded transmission line (case *A*) and a line with an unloaded or reactor-loaded transformer connected at the far end (case *B*) the tests were carried out on a separate testing system. The latter was fed by two generators of 105,000 kva each at Harsprånget. Figure 4 shows a schematic diagram for the testing system.

In the tests for the interruption of an unloaded or reactor-loaded transformer (case *C*) the testing system was so arranged that the 400-kv transformer and the reactors at Harsprånget were interrupted. For this purpose the testing system was fed through the 400-kv transmission line from Midskog with the whole network behind it.

OVERVOLTAGE PROTECTION

THESE TESTS WERE the first field tests on the 400-kv breakers, and even though no entirely new conditions were anticipated on account of the higher system voltage, it nevertheless also was necessary to pay attention to the adequate protection of the plant against overvoltages. This was also of particular importance in view of the fact that the tests were to be carried out at a working voltage as high as 540 kv. This value was chosen instead of 600 kv, since calculations had shown that higher 50-cycle overvoltages were not to be anticipated under these circumstances.

The point calling for primary consideration was the protection of the station at Harsprånget. In the transmission-line tests (cases *A* and *B*) the quantity of energy from the 296-mile (476-kilometer) length of line with double conductors would be so great at high overvoltages that the lightning arresters would be unable to deal with them without the risk of being destroyed themselves. Consequently, it was necessary during these tests to disconnect the lightning arresters and replace them by some other form of overvoltage protection. Rod gaps in series with resistances therefore were selected for this protection. The rod gaps were set to a flashover voltage for switching overvoltages of 1,000 kv crest value to ground.

The purpose of the resistances in series with the rod gaps was to damp the steepness of the voltage wavefront in the event of a flashover at the gap. Each resistance was dimensioned for 200 ohms and was constructed in the form of a mat 25 meters in length. No flashovers occurred at the gaps during the tests, but if this had been the case the resistances would have burnt out owing to the energy developed. Resistances were held in reserve on this account.

In the tests for interrupting small inductive currents (case *C*) the energy in the overvoltages was not so great that the lightning arresters were unable to deal with it, and consequently the 400-kv arresters were employed as the overvoltage protection. The rod gaps then were removed.

The lightning arresters on the 16-kv side of the transformer at Harsprånget as well as all the lightning arresters at Midskog were connected in circuit for all tests. It was found that the arresters sparked over on the 16-kv side at

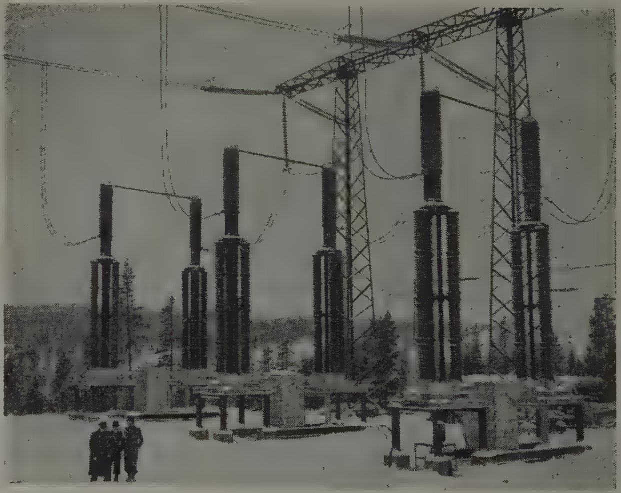

Figure 3. Sprecher and Schuh HPF 316 400-kv oil-minimum circuit breaker

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* The tested circuit breaker was built by Sprecher and Schuh. Other circuit breakers have been ordered from the Delle firm and consequently the tests likewise were regarded as delivery tests for the latter circuit breakers.

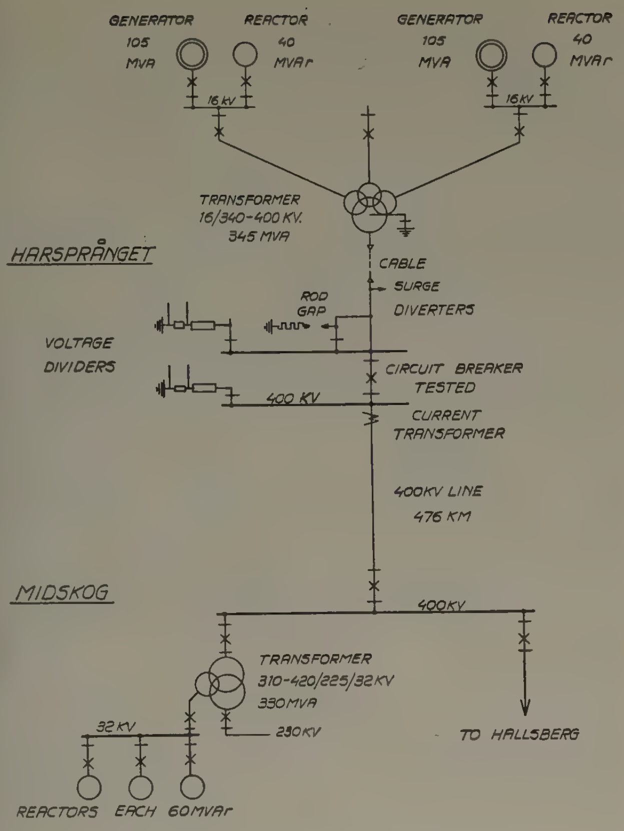

Figure 4. Testing system circuit diagram

Harsprånget in certain of the tests with the oil-minimum circuit breaker.

POTENTIAL DIVIDERS

VOLTAGE MEASUREMENT AT the high voltages and different frequencies here in question is a matter of considerable difficulty, and it was necessary in the first place to decide which form of potential dividers to employ.

When using capacitive potential dividers with a capacitance which is not unduly low, correctly indicated values are obtained within the frequency range applying to switching overvoltages and likewise for service frequencies. On the other hand, a correct indication of a residual direct voltage in the line on the interruption of an unloaded line cannot be obtained for example. A further disadvantage resides in the fact that it is difficult to obtain a current large enough for magnetic oscillograph measurements with medium-sized capacitors.

The resistive potential divider possesses certain limitations owing to the fact that the capacitance to ground of the resistance exercises such an influence at the higher frequency cycles that the potential dividers indicate values that are too low. On the other hand, it also is possible to measure direct voltages with these dividers and they can be dimensioned in such a way that they give a current sufficient for magnetic oscillograph measurements also. The time during which they are connected in circuit must be limited, however, in order to avoid heating up to such an extent as to influence the resistance and jeopardize the equipment itself.

A combination of a resistive and capacitive type of potential divider was employed for these tests at Harsprånget. This type of divider surely is the best one for this type of tests. The high-tension section has a total resistance of 6 megohms and a total capacitance of 120 micromicrofarads. The potential dividers are shown in Figure 5. These potential dividers had an angular error which was less than 1 per cent between 0 and 100,000 cycles and a rating error which was less than 1 per cent between 0 and 5,000 cycles and subsequently rose in such a way that it was about 5 per cent at 100,000 cycles. The influence between the phases was very slight.

The voltages on each side of the circuit breaker and the voltages across it were measured with six of these dividers. The potential dividers gave a current that was adequate for measurements both with cathode-ray oscillographs and magnetic oscillographs. They could not be connected in circuit for periods exceeding some tens of seconds during each test, however, but by arranging for their connection and disconnection by means of remotely controlled isolating switches it was not necessary to connect them up for more than a few seconds.

MEASURING EQUIPMENT

A 10-BEAM CATHODE-RAY OSCILLOGRAPH and a magnetic oscillograph with 12 loops were used for recording the voltages, currents, and so forth.

The six voltages to ground on each side of the circuit breaker and the three voltages across it were recorded by means of the cathode-ray oscillograph. The tenth beam was employed for time calibration. The records were made on $2^3/_8$-inch (6-centimeter) film. The oscillograph's recording speed is as high as 46 feet (14 meters) per second for straight film and 160 feet (50 meters) per second with film wound on a drum. Only straight film was used in these tests, and a recording speed of 16 feet (5 meters) per second met the requirements.

The three currents were recorded by the magnetic oscillograph, the tripping impulse to the circuit breaker and the voltages to ground on either side of the breaker. The latter also were recorded by the magnetic oscillograph to enable them to be studied immediately after the test, which could be done more conveniently with a magnetic oscillogram than with a cathode-ray oscillogram as record-

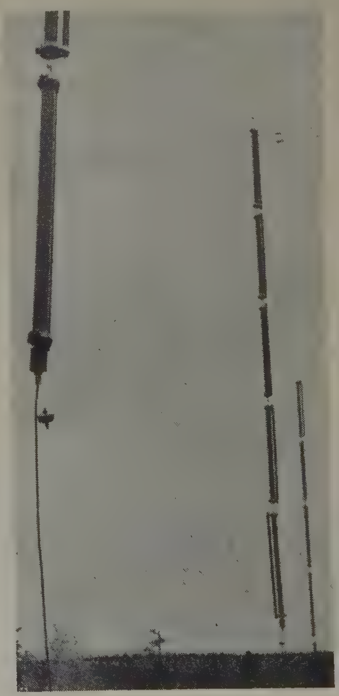

Figure 5. Potential dividers comprising five series-connected parts, each consisting of a resistance of 1.2 megohms and capacitance of 600 micromicrofarads in parallel

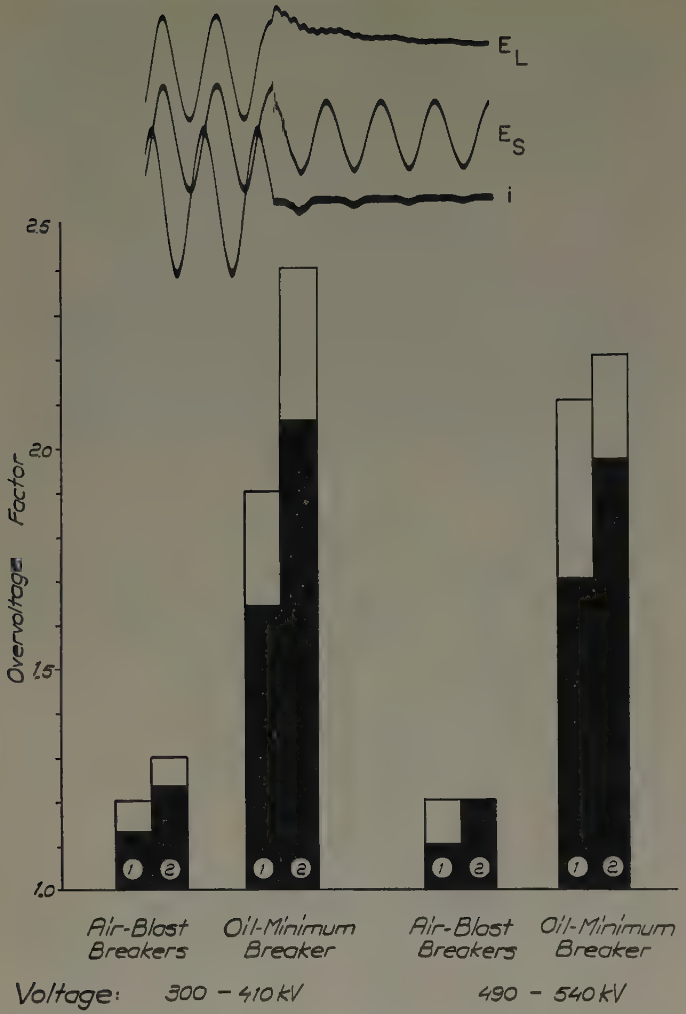

Figure 6 (top). Oscillogram showing the voltage and current in one phase on interrupting a 296-mile (476-kilometer) unloaded transmission line with an ASEA circuit breaker: *e_L—voltage phase-ground on the line side; e_S—voltage phase-ground on the station side (prior to interrupting 539 kv); i—current in the same phase (prior to interrupting 600 amperes).* **Figure 7 (bottom). Diagram showing the overvoltage factors measured on interrupting 296-mile unloaded transmission line†**

ing with the magnetic oscillograph was done with a paper strip 30 centimeters in width and the recording speed did not exceed about 3.3 feet (1 meter) per second. In addition the records made with the magnetic oscillograph were regarded as a reserve to the cathode-ray oscillograph records in case the latter were unsuccessful in any instance.

A comparison between the overvoltages recorded by the cathode-ray and magnetic oscillographs respectively showed that the same results had been obtained with the air-blast circuit breakers when no restriking occurred. On the other hand, quite appreciable differences were obtained in the results of certain tests with the oil-minimum circuit breaker. It was found that at steep restriking fronts, the loops which had natural frequencies of about 5, 000 and 10,000 cycles were unable to follow and gave a superposed oscillation which recorded higher overvoltages than those actually set up.

TEST RESULTS

THE SAME SERIES OF tests were carried out with each circuit breaker, and comprised a total of 29 tests per breaker. A report on the results obtained with the different types tested is given in the following.

1. Interruption of an Unloaded Transmission Line. When interrupting an unloaded transmission line, that is, a capacitive load, the line on being interrupted will be charged with a direct voltage which is about equal to the amplitude value of the voltage prior to interruption. The difficulty encountered in interrupting an unloaded line consists primarily in the fact that when no discharge takes place across the breaker, a voltage equal to the sum of the amplitude values will be obtained 1/2 cycle after interruption. If this voltage exceeds the surge-resisting strength of the circuit breaker, a restrike is obtained. The voltage on the line can be reduced, and therefore the voltage across the circuit breaker and the risk of restriking also by connecting a nonlinear resistance in parallel with the break.

These tests were made with only one length of line, namely 296 miles (476 kilometers). The line has double conductors. The test results therefore afford no information as to whether the difficulties would be modified with other lengths of line. There is no reason to assume, however, that some other length of line would increase the difficulty of interruption appreciably.

Nine tests were carried out with each circuit breaker for the interruption of an unloaded line. These were distributed in such a way that a preliminary test was made at 300 kv, 5 tests at 410 kv, 1 test at 490 kv, and 2 tests at 540 kv. The voltage at the open line terminal was about 15 per cent higher.

The capacitive generation of the line at 410 kv was about 300,000 kva and about 550,000 kva at 540 kv. On two of the testing days the corona losses on the line were exceptionally high owing to hoarfrost and ice loading of the line. At 400 kv the losses were about 12,000 kw while at 540 kv they were about 55,000 kw. These losses rendered the load somewhat less capacitive and it is possible that it facilitated interruption to some extent, and thus reduced the switching overvoltages.

The overvoltages set up on interruption are indicated in the form of an overvoltage factor. This is defined here as the relation between the highest amplitude value of the overvoltage to ground and the phase voltage's amplitude value prior to interruption. It should be noted that this definition includes the change of the service-frequency voltage obtained on the feeding side at interruption. The system itself thus produces a decrease in voltage when interrupting an unloaded line, whereas an increase is obtained when interrupting an inductive load. At the tests with breaking an unloaded line the voltage to ground after the breaking was about 70 per cent of the voltage before. Figure 6 is an oscillogram showing the voltages on the station and line sides of the circuit breaker and the current in one phase on interrupting an unloaded line by means of an air-blast circuit breaker with a protective resistance. On the oscillogram the current through the nonlinear resistors after the interruption also can be seen.

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† Unfilled stem—maximum value; filled stem—mean value; (1) on the station side; (2) on the line side.

The overvoltage factors obtained when interrupting an unloaded line are shown graphically in Figure 7. As may be seen from the results, the highest overvoltage factors on the station side of the circuit breaker were 1.2 for the air-blast circuit breaker and 2.1 for the oil-minimum circuit breaker. The corresponding figures on the line side were 1.3 and 2.4. When comparing these results it should be observed, however, that the air-blast circuit breakers were equipped with nonlinear resistances, whereas the oil-minimum circuit breaker was not so equipped.

If it is possible to prevent the breaker from restriking when interrupting an unloaded line, the overvoltages will be very small. This is seen, among other things, from the results of these tests in which the air-blast circuit breakers did not restrike in any instance and the overvoltages were likewise insignificant. Thus, with a suitably dimensioned circuit breaker this form of interruption does not offer any difficulties from the viewpoint of overvoltages.

With the oil-minimum circuit breaker's method of operation it is difficult to prevent restriking in this case. When restriking occurs, somewhat higher overvoltages will be obtained. An oil-minimum circuit breaker also can be equipped with nonlinear resistances connected in parallel to the breaks, and these contribute towards reducing the switching overvoltages. The construction of the resistances for the oil-minimum circuit breaker tested in this case had been completed, but in view of the fact that the overvoltages were not very high it was not considered justifiable to complicate the arrangement of the breaker by mounting these resistances, since in addition to the resistance itself, an interrupting device for the current flowing through the resistance is required.

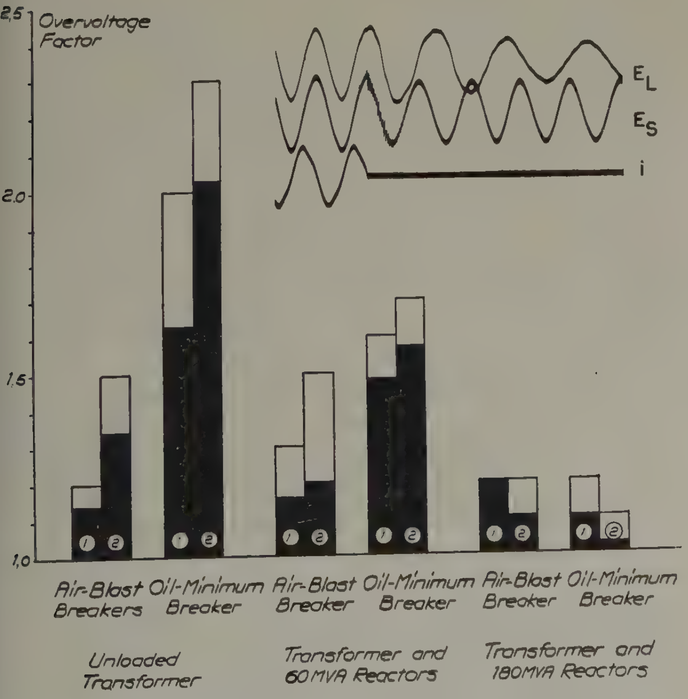


Figure 8 (top). Oscillogram of voltage and current in one phase on interrupting a 296-mile transmission line loaded with a 330,000-kva transformer and a 60,000-kva reactive load, with a Brown Boveri circuit breaker: *e_L—voltage phase-ground on the line side (prior to interrupting 408 kv); e_S—voltage phase-ground on station side; i—current in the same phase (prior to interrupting 245 amperes).* **Figure 9 (bottom). Diagram showing the overvoltage factors measured on interrupting a 296-mile transmission line with a reactive load†**

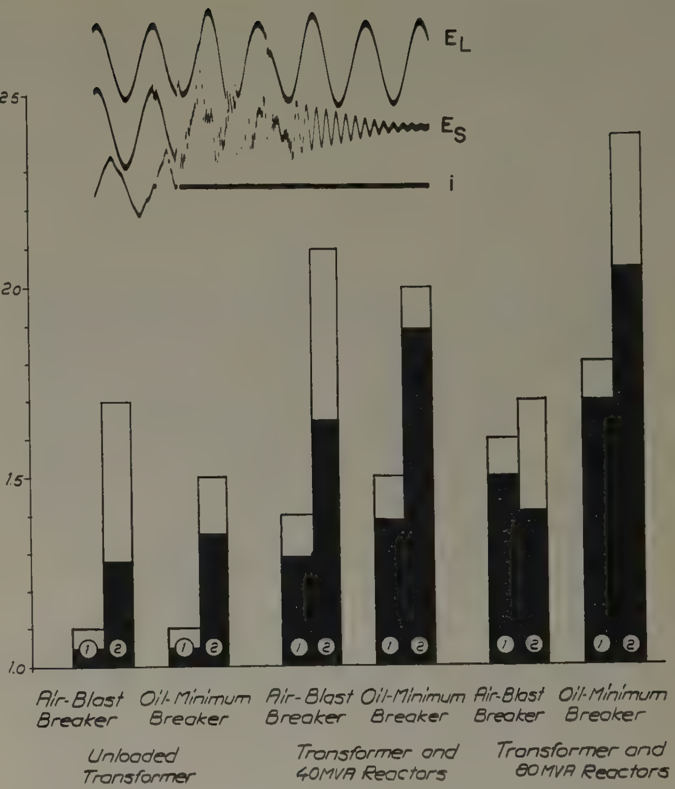


Figure 10 (top). Oscillogram showing the voltage and current on interrupting a 345,000-kva transformer carrying a 40,000-kva reactive load, with a Sprecher and Schuh breaker: *e_L—voltage phase-ground on the feeding side (prior to interrupting 414 kv); e_S—voltage phase-ground on the interrupted side; i—current in the same phase (prior to interrupting 76 amperes).* **Figure 11 (bottom). Diagram of overvoltage factors measured on interrupting a reactor-loaded or unloaded transformer†**

2. *Interruption of Transmission Lines Carrying a Reactive Load.* When interrupting a line which is loaded at its far end with a reactor-loaded or unloaded transformer, an oscillation of energy is produced on interruption between the capacitance of the line and the inductive load. At the outset the voltages have approximately the same amplitude value as the voltages prior to interruption. The oscillations, which in these tests had frequencies between 25 and 40 cycles, were damped relatively slowly, particularly at the highest frequencies, that is to say, when the inductive load consisted of a transformer and three reactors. Figure 8 shows an oscillogram taken from this case.

Because of the different frequencies set up on either side of the circuit breaker after interruption, phase opposition is obtained across the breaker twice per cycle in the oscillation frequency. This causes special stresses for the breaker, particularly in the type equipped with nonlinear protective resistances. This was confirmed by the tests carried out in connection with the placing in service of the 400-kv system when some of the resistances were thermally overloaded. In view of the experience gained here the dimensions of the resistances were altered, and the tests at Harsprånget showed that with the present construction of the circuit breakers, this form of interruption does not occasion any greater difficulties than the interruption of unloaded lines.

In this case eight tests were carried out with each circuit breaker, two in which the load on the line consisted of a 330,000-kva unloaded transformer, and six tests in which the same transformer was loaded with reactors. The highest overvoltage factors and the mean value of the highest overvoltage factors in each test are shown in Figure 9. The highest overvoltage factors on the station side were 1.3 for the air-blast circuit breakers and 2.0 for the minimum-oil circuit breaker. The corresponding values on the line side were 1.5 and 2.3. As may be seen from Figure 9, the overvoltages are greater, the lower the reactive load on the line is. Thus, the most troublesome case occurs when the reactive load consists of an unloaded transformer.

3. Interruption of a Reactor-Loaded or an Unloaded Transformer. The difficulties arising when interrupting a small inductive load such as an unloaded transformer or a transformer loaded with reactors consists primarily in the fact that interruption takes place before the current goes through zero (forced interruption). A certain amount of energy which is proportional to the square of the interrupted current will remain in the disconnected part. Oscillation then will be set up in the latter which gives rise to overvoltages, see Figure 10.

For the tests at Harsprånget relating to the interruption of an unloaded transformer a 3×115,000-kva transformer was employed. Its no-load current lay between 20 and 25 amperes at voltages between 415 and 445 kv, within which voltage range the tests were carried out. In the tests with a reactor-loaded transformer, the reactive load was 40,000 and 80,000 kva respectively. The corresponding currents were about 80 and 140 amperes.

The interrupted part also included 360 feet (110 meters) of 400-kv cable which, owing to its appreciable capacitance, may have exercised a reducing effect on the switching overvoltages.

In this case 12 tests were carried out with each of the circuit breakers, and were distributed in such a way that 5 tests were made with an unloaded transformer, 5 tests with a transformer loaded with a reactive power of 40,000 kva, and 2 tests with 80,000 kva.

The highest overvoltage factors and the mean value measured during the tests are given in Figure 11. The overvoltages were relatively low when interrupting an unloaded transformer. The highest figure obtained on the feeding side was 1.1 for both types of breakers. On the side interrupted the highest overvoltage factor for the air-blast circuit breakers was 1.7 and 1.5 for the oil-minimum breaker.

When the transformer was loaded with reactors, the highest overvoltage factors on the feeding side were 1.6 for the air-blast circuit breakers and 1.8 for the minimum-oil type. The corresponding values on the side interrupted were 2.1 and 2.4.

Table I. Highest Overvoltage Factors Measured

Form of Interruption	Air-Blast Circuit Breaker	Oil-Minimum Circuit Breaker
Interruption of:		
An unloaded transmission line	1.3	2.4
A line loaded with a no-load transformer	1.5	2.3
A line loaded with a transformer plus reactors	1.5	1.7
An unloaded transformer	1.7	1.5
A reactor-loaded transformer	2.1	2.4

These overvoltage factors also include the voltage rise resulting on the feeding side when the inductive load is interrupted. This voltage rise was 25, 15, and 5 per cent, the highest value being obtained with the maximum reactive load and the lowest with the transformer unloaded.

It will be seen from the results that at this voltage the interruption of an unloaded transformer causes very moderate overvoltages both with the air-blast circuit breakers and the oil-minimum circuit breaker. That an interruption of this form can be handled relatively easily by oil-minimum circuit breakers may be seen from the fact that there were few restrikes and in many of the tests none occurred at all.

On the other hand, the interruption of heavy inductive currents gave rise to higher overvoltages. With regard to the air-blast circuit breakers the results show that the most troublesome case, that is to say, the case entailing the highest overvoltages, occurred when interrupting a transformer with a 40,000-kva reactive load, that is, a current of about 80 amperes. The oil-minimum circuit breaker, on the other hand, gave the highest overvoltages when interrupting a transformer with a reactive load of 80,000 kva, that is, a current of about 140 amperes.

Earlier tests[1,2] have shown that with an unloaded transmission line connected to the feeding side the overvoltages may be higher with this form of interruption. It was not possible to investigate a case of this kind during the present tests however.

SUMMARY

Three different types of 400-kv circuit breakers have been tested in the Swedish network. The cases of interruption tested comprised the breaking of an unloaded transmission line, a line carrying a reactive load, an unloaded and reactor-loaded transformer. The highest overvoltage factors measured have been compiled in Table I. As the table shows, the highest overvoltage factor is 2.4 and is thus lower than the figure of 2.5 guaranteed for the circuit breakers.

From a general point of view the results tend to show that the switching overvoltages will be less in a 400-kv network than at lower voltages. It is nevertheless possible that the conditions at Harsprånget were somewhat more favorable than those normally prevailing, owing among other things to the inclusion of 360 feet (110 meters) of 400-kv cable in the testing network.

REFERENCES

1. The Field Testing of 220-kv Air-Blast Circuit Breakers. **L. R. Bergström, Uno Sandström.** *Electrical Engineering*, volume 70, February 1951, page 118.

2. Line-Dropping and Reactor-Load Interruption Tests With a Brown Boveri 220-kv Air-Blast Circuit-Breaker in the Stadsforsen Power Station (Sweden), **P. Baltensperger.** *The Brown Boveri Review* (Baden, Switzerland), December 1951, pages 391–410.

Parallel Operation of Aircraft A-C Generators

L. R. LARSON
MEMBER AIEE

THE ELECTRIC POWER requirements for aircraft have shown an increased demand for a-c power. Repeatedly, weight studies made by airframe manufacturers have shown a saving through the generation and distribution of a-c power directly rather than the generation of d-c power and the ultimate conversion to meet the a-c power requirements. In addition, the over-all efficiency of the a-c system is higher than that of a d-c system with conversion to a-c power. For the most part, the a-c power requirements have been met through the use of single-generator systems or combinations of single-generator systems using split bus arrangements. However, the need for higher reliability systems having greater reserve capacity and making better utilization of generator capacity through the diversification of load equipment leads to the conclusion that parallel systems should be used in future aircraft. Reliable parallel operation of a-c machines requires the proper integration of many components.

The electric system should require little or no supervision for its reliable operation. A reasonable design objective for the a-c system is that it should be as easy to operate as the older d-c system. The operator, having selected the generators to be used for a particular operation, should not be required to establish manually the conditions necessary for satisfactory operation. Systems must be as simple as is compatible with the prior requirement of automaticity.

The following design principles can be applied during consideration of a particular system configuration:

1. The characteristics of the individual components must be carefully co-ordinated to meet the steady-state and transient requirements that are placed on the system by the load equipments.
2. Though the control and protective devices must be co-ordinated with the remainder of the system, they should be physically integrated with the associated equipment whenever possible.
3. Control or protective devices should not be operated through common circuitry or elements so that the failure of the circuit or elements can result in simultaneous loss of control and protection.
4. Protective devices must be carefully co-ordinated so that during system malfunction the proper protective device provides the correct operation. Simultaneous tripping of cascaded protective devices cannot be permitted while retaining the required degree of system reliability.
5. The principle that one fault shall not cause system collapse is of fundamental importance in discussing systems or components that are required for safety of flight items.

The problem of satisfactorily duplicating the steady-state and dynamic characteristics of a given generator system with a second system for parallel operation can become very difficult if machines of different ratings or of different manufacture are to be used. In addition, certain control and protective functions must be included to insure reliable system operation. Past experience has shown the desirability of using differential load division circuits on machines being operated in parallel. These requirements are based on the ultimate achievement of 90 per cent of the total generator capacity for system utilization. Consequently, these circuits must be correlated for the governors of the prime movers in the case of real load division and for the voltage regulators in the case of reactive load division. The sensitivities of these circuits must be defined fully if machines and drives of different manufacture are to be operated successfully in parallel.

Before the design of a particular system can be considered complete, the operation of that system for various abnormal operating conditions must be analyzed. An integrated system should be capable of recovering from abnormal conditions without damage to either the power system components or to the load equipments. In addition, the recovery of the system should be to a stable operating condition within the design range.

A few broad conclusions can be drawn from the foregoing discussion:

1. Due to the many divergent conditions encountered in obtaining proper system co-ordination, experience with complete system operation is necessary for intelligent selection of control and protective functions as well as basic system components.
2. Proper integration of the various items used in establishing a system is necessary for satisfactory system performance.
3. Well-defined design data, or preferably, experimental test data, are necessary to establish detailed component requirements.
4. The use of mismatched system components can cause serious system malfunction.
5. Consideration should be given to the possibility of parallel operation of the aircraft with external or ground power units.
6. Continued growth of parallel operated systems may require specification of specific design data for drives, generators, regulators, and other system components.

Digest of paper **53-372**, "Parallel Operation of Aircraft A-C Generators," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Aircraft Electric Equipment Conference, Seattle, Wash., September 30–October 2, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

L. R. Larson is with the Naval Research Laboratory, Airborne Systems Branch, Washington, D. C.

INSTITUTE ACTIVITIES

1954 Winter General Meeting to Offer 90 Technical Sessions and Conferences

Ninety technical sessions and conferences already are planned for the 1954 Winter General Meeting to be held January 18–22 in New York, N. Y., at the Hotels Statler and McAlpin. Since at this time last year only 70 sessions were scheduled, it must be assumed that this year's meeting again will be 20 per cent larger than the meeting which was held last January. This would point to a possible registration of 5,500.

TECHNICAL SESSIONS

As this issue goes to press, the AIEE Committee on Technical Operations is not yet able to detail the committees who are sponsoring technical sessions throughout the 5-day meeting. However, all of the 39 technical committees of the Institute are planning either technical sessions or committee meetings or both. A detailed breakdown of these plans will appear in a forthcoming issue.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent prior to January 4 directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request and a copy sent to the vice-chairman of the Hotel Accommodations Committee, D. V. Buchanan, Room AU16, Consolidated Edison Company of New York Inc., 4 Irving Place, New York 3, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 17, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels on the list.

Hotel rooms have been reserved at the following:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 6.00 to $11.00
Double room, double bed	8.00 to 14.00
Double room, twin beds	9.00 to 16.00
Studio type	15.00 to 18.00
Parlor suites	25.00 to 27.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 6.00 to $ 8.00
Double room, double bed	8.50 to 10.00
Double room, twin beds	10.00 to 13.00

Hotel McAlpine, Broadway and 34th Street

Single room with bath	$ 4.50 to $ 9.25
Double room, double bed	7.00 to 13.50
Double room, twin beds	8.50 to 13.50

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 6.00 to $10.00
Double room, double bed	9.00 to 14.00
Double room, twin beds	10.50 to 16.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 5.00 to $ 7.00
Double room, double bed	8.00 to 11.00
Double room, twin beds	9.00 to 12.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	9.50 to 12.50
Double room, twin beds	11.00 to 15.00

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 6.50 to $14.00
Double room, double bed	11.50 to 17.50
Double room, twin beds	13.50 to 20.00

Rates are subject to 5 per cent New York City hotel room tax

SOCIAL ACTIVITIES

Theater tickets will be provided for those out-of-town members wishing to see the hit stage shows. However, the committee under the chairmanship of S. Friend, Jr., feels it is inadvisable to give at this time a specific listing of the stage shows that will be playing during the meeting. A complete listing of the shows is scheduled for the December issue of *Electrical Engineering*, and it is requested that all inquiries be deferred until that time.

Tickets to available radio broadcasts and television shows also will be provided at the time of registration for the meeting.

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held on Tuesday evening, January 19, 1954, at the Hotel Commodore. Reservations should be sent to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., at an early date.

J. G. Derse, chairman, has announced that the dinner-dance will be held on Thursday evening, January 21, 1954, in the Grand Ballroom of the Hotel Statler. Music and general arrangements will be the same as those which proved so enjoyable last year. Dress will be formal. Plan now and write soon for reservations at tables for ten. Tickets will be $12 each. Address requests to the Dinner-Dance Committee

Informal Tea

Inaugurated last year, this social gathering before the formal program begins was enjoyed by many members and guests. It is hoped that more will participate this year—on Sunday afternoon, January 17, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this same period the registration facilities will be open for those wishing to avoid the Monday morning rush.

Fall General Meeting Inspection Trip

An inspection trip is scheduled to the Platte Pipe Line Company in the Power and Light Building, headquarters of the Kansas City Power and Light Company. Here visitors may inspect the microwave equipment, and also see Kansas City from the top of this highest building in Missouri

AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

The Ladies Entertainment Committee, under the chairmanship of Mrs. E. S. Banghart, is arranging a program of social events of interest for the ladies. On Monday afternoon, January 18, there will be the usual "Get Acquainted" Tea in Ladies Headquarters in the Statler.

INSPECTION TRIPS

The Inspection Trips Committee, under the chairmanship of D. E. Sullivan, is working on a program which it is hoped will be of interest to members attending the meeting, particularly to those from out of town. Plans are under way to schedule again some of the trips on last year's list which proved so popular, such as those to the Brookhaven National Laboratory and to Radio City Music Hall.

WINTER GENERAL MEETING COMMITTEE

Members of the 1954 Winter General Meeting Committee are: C. T. Hatcher, chairman; A. J. Cooper, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, chairman, Committee on Technical Operations; R. T. Ferris, publicity; L. F. Stone, general session; J. G. Derse, dinner-dance; D. E. Sullivan, inspection trips; C. F. Bolles, smoker; Sidney Friend, Jr., theater-radio-television; W. G. Vieth, hotel accommodations; H. E. Martin, registration; Mrs. E. S. Banghart, ladies' entertainment; R. T. Weil, monitors.

Future AIEE Meetings

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—closed*)

AIEE-IRE-ISA Conference on Electronic Instrumentation in Nucleonics and Medicine
New Yorker Hotel, New York, N. Y.
November 18–20, 1953
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Eastern Computer Conference
Statler Hotel, Washington, D. C.
December 8–10, 1953
(*Final date for submitting papers—closed*)

Winter General Meeting
Statler Hotel, New York, N. Y.
January 18–22, 1954
(*Final date for submitting papers—closed*)

Scintillation Counters Conference
Washington, D. C.
January 26–27, 1954
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM West Coast Computer Conference
Ambassador Hotel, Los Angeles, Calif.
February 10–12, 1954
(*Final date for submitting papers—November 10*)

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 15–16, 1954
(*Final date for submitting papers—January 15*)

Conference on Feedback Control
Claridge Hotel, Atlantic City, N. J.
April 22–23, 1954
(*Final date for submitting papers—January 25*)

AIEE-IRE-RETMA-WCEMA Electronic Components Conference
Washington, D. C.
April 27–29, 1954
(*Final date for submitting papers—January 27*)

North Eastern District Meeting
Schenectady, N. Y.
May 5–7, 1954
(*Final date for submitting papers—February 4*)

Appliance Technical Conference
Morrison Hotel, Chicago, Ill.
May 17–19, 1954
(*Final date for submitting papers—February 17*)

Electric Welding Conference
Milwaukee, Wis.
May 19–21, 1954
(*Final date for submitting papers—February 19*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(*Final date for submitting papers—February 24*)

Summer and Pacific General Meeting
Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—March 23*)

Area's Industries Provide Main Topic at Middle Eastern Meeting in West Virginia

In keeping with the dominance of the coal and chemical industries of West Virginia, emphasis was placed on these subjects at the 1953 AIEE Middle Eastern District Meeting held in the Daniel Boone Hotel, Charleston, W. Va., September 29–October 1. Nearly 470 members and guests attended the technical sessions and enjoyed the entertainment provided by the West Virginia Section.

Five sessions were devoted to all phases of coal mining and handling and five sessions dealt with the chemical industry; 17 papers were presented in four sessions on power generation, transmission, and distribution, with additional papers on rail transportation and general industry applications. Because of the increased demand for engineers and the growing dependence of industry on the engineer for management functions, four papers were devoted to management problems.

All the luncheons and evening entertainment were for both members and their ladies. Outstanding speakers were enjoyed at the luncheons and in the evenings lighter entertainment was provided at the "Guys and Gals" party on Tuesday and the banquet on the following evening.

GENERAL SESSION

After welcoming the visitors to Charleston, John C. Fox, the honorary chairman, who presided at the General Session on the morning of September 29, presented West Virginia's governor, the Honorable William C. Marland, who welcomed the members to the state and told how it had benefited through electrical developments. AIEE Vice-President W. B. Morton acknowledged the work of the meeting's committees and thanked them for their efforts.

Julius Strasbourger introduced Miss Vivien Kellems (M'36), president of the Kellems Company, whose subject, "Toil, Taxes, and Trouble," she said, at the beginning, was nonpolitical. To illustrate her opinion of the present system of taxation, Miss Kellems related some of the reasons which irritated our American ancestors to the point that they told George III of Great Britain that: "Taxation without representation is tyranny." The Continental Army of the 18th century did not fight for "idealistic slogans" as we of the present century have done; they fought for and won freedom to govern themselves. However, the Connecticut manufacturer feels that this freedom is being placed in jeopardy by at least three things, "nibbles at our freedom." These are

1. "Tax spies"—informers who are paid by the government when they give information against their neighbors on matters of income tax. (She went on to say that if we have income taxes, everyone should pay, but that the government should not pay "spies.")
2. The fact that, in many schools, children are being taught how to fill out tax questionnaires. She said, "Our children should be taught to be opportunity-minded, not security-minded."
3. The fact that government representatives are checking on a house-to-house basis in several locations, mainly in New England, to determine if people are paying their taxes properly.

Miss Kellems believes the only way the Federal Government can balance the budget is to stop taxing as it is now and have just one out-in-the-open tax—one on all sales—a tax which though relatively small will be visible and painful. The Government then should make a budget to fit its income, not try to make its income fit a budget. She maintained that the Federal Government should get out of business, that it should take some of the 200 billion dollars its business is worth and pay off the National Debt.

In answering questions from her listeners after her speech, Miss Kellems stressed that our school children should be taught that patriotism means love of freedom and not future security in a job.

ENTERTAINMENT

The General Meeting luncheon on Tuesday was presided over by John Vodar, Jr., chairman of the West Virginia Section. He introduced John Peal, president of the Charleston City Council, who welcomed the visitors to the city. Mr. Peal was followed by C. W. Schweers, vice-president of Allis-Chalmers Manufacturing Company, who pointed out that electrical engineers should be more interested in their own as well as the country's future.

Left to right: John Vodar, Jr., chairman of the West Virginia Section, chats informally with Institute officers, Secretary H. H. Henline, President Elgin B. Robertson, and Vice-President W. B. Morton

He told how electrical luxury is the keynote of our society to-day; how it has made our living easier. Because of continuous research, yesterday's luxuries have become today's necessities. Engineering and sales are closely allied; engineers should bear in mind that they have to sell management on new methods, new materials, and on old ones which have been improved, and above all, they should remember that markets must be created for their products.

At the Wednesday luncheon sponsored by the AIEE Ohio Valley Section, Dr. Stewart Smith, president of Marshall College, Huntington, W. Va., spoke on the topic, "Freedom to Speak." While emphasizing that freedom can be dangerous if it is not coupled with personal responsibility and knowledge, Dr. Smith decried those who believe that they are able to decide what is good or bad for their fellow citizens.

Dr. John O. Christianson, University of Minnesota, through the courtesy of General Motors Company, was the guest speaker at the banquet held on Wednesday evening in the ballroom, and his theme was "Our Part in These Times." He warned that we cannot let our freedom weaken; our homes, our schools, our communities must be kept strong. He told about Germany's great scientific past and how she "lost her soul" to Nazism and as a nation fell under Hitler. We as engineers may make great progress in science, but we must never lose track of our national progress—as trustees of the past, we must keep civilization strong.

The speaker stressed that engineers should read the lesson of history and realize from that that Communistic "nibblings" at our youngsters makes them doubt the value of our freedom. We owe it to the next generation to see that they get the proper heritage. He left this thought with his listeners, "What you belong to is more important than those things which belong to you."

TECHNICAL SESSIONS

In the session on railway transportation, two District papers and two technical papers were presented on Tuesday afternoon with L. W. Birch, Ohio Brass Company, in the chair.

The first District paper was given by J. C. Fox, Virginian Railway Company, on "Electricity as Applied to Railroads," which was an interesting pictorial history of the part electricity has played in the railroad field other than in locomotion: fluorescent lighting in shops, roundhouses, passenger cars, signals, welding, and so on.

K. O. Anderson, General Electric Company, read his technical paper, "Wanted—A Modern Diesel-Electric Rail Car," in which he brought out that this type of car, which had been considered more or less passé for a generation, was being ordered in increasing quantities as railroads were finding it an efficient and economical means of providing added passenger service on short runs. The author set forth the advantages of a high-speed engine (1,800 to 2,100 rpm) over one operating at 1,000 rpm, as it has lower weight, is smaller, and probably has a lower cost.

Split-pole exciters have given good performance for years and because of this they have a place in the future of diesel-electric locomotive control in switching and light road service. This was brought out by H. R. Stiger, General Electric Company, in his paper, "Split-Pole Exciters—Their Design and Application in Diesel-Electric Locomotives."

The final paper of the session was given by T. F. Perkinson, General Electric Company, and was entitled, "Some Current Aspects of Railway Electrification." After describing some of the newest electric locomotives, the speaker brought out that where traffic is heavy, the electric locomotive is the most economical, as the cost of operation of an electrified system is less than for a diesel under present price conditions. In European and other countries the trend is toward electrification because they do not have economical oil supply for diesels.

On Tuesday afternoon, the first of several sessions on mining was held, with R. B. Moore, General Electric Company, presiding.

W. R. Morton, General Electric Company, discussed the "Technical Aspects of Electric Equipment in Coal Preparation Plants." The use of processing equipment in coal preparation plants has greatly increased, due to the desire for cleaner coal; therefore, the electrical requirements of the plant should be studied carefully with regard to total power, its distribution, use, and control, and the selection of cable.

The controversial subject of ground impedance was presented by L. H. Harrison, United States Bureau of Mines, in a paper, "The Effect of Reactive Components in the Measurement of Grounding Circuits." In measuring earth currents of a power system, Ohm's law does not always hold; therefore, measurement of ground resistance by the use of commercial ground testers may give reduced values, due to reactive components. Also, earth impedance varies inversely with frequency. Further study is needed to insure adequate protection of power systems, and to promote the development of voice communication through earth strata.

"What Overcurrent Settings for D-C Mining Feeder Circuit Breakers?" was discussed by Donald J. Baker, I-T-E Circuit Breaker Company, and Clyde L. Brown, United States Bureau of Mines. They said that the mining industry had expected too much overcurrent protection from too few devices; also, simple formulas to determine safe current settings were not available to the average electrician. Such formulas, and tables based on them, were presented.

H. P. Musser, West Virginia Engineering Company, showed the relation between horsepower and demand in his paper, "Characteristic Power Requirements for Performing Various Functions in Underground Coal Mines." The importance of voltage regulation on the operation of automatic miners and the relation between energy and demand in the operation of loading machines were discussed.

In the absence of Earl Browning, Westinghouse Electric Corporation, the Wednesday morning session on electrothermal topics was presided over by J. H. Schrameck of the same company.

Mr. Schrameck also presented "A New Compressed Air Arc Furnace Breaker," which described the mechanism and operation of this device. It is especially suited to such use by virtue of its accessibility, its control of switching transients, its ability to handle short circuits on the primary of the furnace transformer, and its ability to withstand highly repetitive operation.

"A New High-Current Switch for Electrochemical and Electrothermal Applications" was presented by H. W. Graybill, I-T-E Circuit Breaker Company. The history of early types of cell short-circuiting switches was related, including the link and wedge types. The new switch operates on a rotary principle, which insures a high-pressure rubbing contact.

H. S. Newall, Pittsburgh Lectromelt Furnace Corporation, presented "Electrothermic Reduction of Ores." The various types of furnaces used in this field were discussed.

Two sessions were devoted to the problems of management, at which four District papers were presented. The chairman of the Wednesday morning session was E. C. Jones, West Virginia University; and Edward Knight, Virginian Electric, Inc., presided over the Thursday morning session. Two papers were devoted to the problems involved in the training of young engineers for managerial positions and one was on the selling of a company to engineers in college.

E. J. Ryan, E. I. du Pont de Nemours and Company, presented "No Couches—Just Chairs." This paper created much interest as it described means by which employees of the company have been assisted from a psychiatric point of view. Absenteeism has been reduced materially through a study of the causes behind minor ailments and in most cases sending the employees back again to their jobs.

On Wednesday afternoon, a session on power distribution and application was held, with E. L. Munday, Jr., Appalachian Electric Power Company, as chairman.

"240/416-Volt 3-Phase 4-Wire Power and Lighting Supply for Modern Industrial Plants," by William Shuler, The Dayton Power and Light Company, was presented by his associate, D. D. Colker. Advantages of this system over the 277/480-volt system are: (1) Improvement in power factor and efficiency of machine-tool motors; (2) Fluorescent lamps do not require new accessories; (3) The phase-to-neutral voltage is within the Underwriter's Laboratory limit. In the discussion, J. W. St. Andre, *Factory* magazine, pointed out that from the standpoint of industrial users, the problem is not too-high voltages, but to get present voltages up to stated values. Current burns up motors; therefore, the voltage must be brought up to cure overloads.

Carl R. Loper, Sr., Allis-Chalmers Manufacturing Company, described "Dielectric Heating Applications for Sand Core Drying." Such heating equipment enables many foundries to organize their core-baking on a production-line basis. Applications include drying cores for such different-sized units as very complex jet-engine castings, hollow mine-car wheels, and intricate small parts. In the discussion, it was brought out that clay and wood also can be dried by this means and veneers can be applied with dielectrically heated waterproof resins.

The advantages of "Neutral Grounding of Industrial Power Systems" were enumerated by L. J. Carpenter, General Electric Company. By means of a model circuit, he demonstrated that intermittent ground faults may raise the voltage up to five times normal on a 480-volt ungrounded system, but when the system is grounded, the voltage will remain near normal.

"Modernizing and Expanding Industrial Power Systems," by W. R. Crites, showed how higher distribution voltage and the load-center power system are the most promising changes to make if the optimum return on modernization expense is to be realized.

In a Wednesday afternoon session in which electric equipment applications in the chemical and petroleum industries were considered, three District papers on motors, controls, and switchgear were given. Paul Barlow, Magic Valley Sales Company, was the chairman.

E. F. Greiwe, Allis-Chalmers Manufacturing Company, considered that part of mechanical design of motors which deals with enclosures and auxiliary equipment that affords motor protection as used in chemical plants and refineries. This paper was followed by one in which the a-c controls for these industries were described by Lewis Daughtrey, Jr., Rowan Controller Company, who traced the history of controllers' development from 1927 to the present. He gave special attention to the National Electrical Manufacturers' Association code pertaining to this subject, defining and interpreting some of the notes in the code which had proved confusing.

D. Dalasta, Allis-Chalmers Manufacturing Company, described primary switchgear arrangements for chemical plants, comparing the several patterns in which this equipment can be arranged.

The chemical session held on Thursday morning was conducted by J. Z. Linsenmeyer, Westinghouse Electric Corporation.

"Electric Heat in the Chemical Industry" was presented by W. S. Eyth, Edwin L. Wiegand Company. The ease with which high temperatures are reached, without accompanying high pressures, and the instant on-off control possible are encouraging the use of electric heat in industry. The jacketed kettle, the direct immersion installation, and the clamp-on strip, are some of the types of electric heat devices. As most chemical operations involve explosive or highly combustible material, the importance of electric heat for safety may be the primary consideration in many installations.

H. Carl Bauman, American Cyanamid Corporation, discussed the "Cost of Purchased Power Versus Generated Power in Chemical Plants." The choice between these power sources involves careful study of many physical and economic considerations. Generated power may be more economical where complete independence, lack of purchase power, need of reliability at all times, very large requirements, or need of low-pressure process steam are factors; purchased power, where ready availability, labor problems, rapid expansion, and relative rates of return are factors.

"The Application of Mercury-Arc Rectifiers in the Electrolytic Industry" was given by W. E. Gutzwiller, Allis-Chalmers Manufacturing Company. The electrolytic industry uses the largest proportion of the chemical industry's annual 30 billion kilowatt-hour d-c consumption; 4 million kilowatts of generating and converting equipment is required. Turbine generators, synchronous or rotary converters, motor-generator sets, gaseous rectifiers, and mechanical rectifiers are some of the means used to this end. Of these, the most frequently used is the mercury-arc rectifier, because it does not require continuous attendence, is immune to corrosion and dust, is highly stable, and has a high availability factor. However, where low voltage, and the ability to carry current in either direction, are required, the mechanical rectifier should be considered.

A highlight of the Thursday afternoon meeting on mining was the sound film, "A Continuous Miner," by J. W. Heimaster, Carbide and Carbon Chemicals Company. L. H. Harrison, United States Bureau of Mines, was chairman.

The film showed the operation of a machine developed for the specific purpose of local coal mining by the author's company, a producer of chemicals, due to the the dwindling natural gas supply. A feature of the device is sensing and control from outside the mine shaft by means of sensing devices on the digging head, and a directional display on two cathode-ray tubes. Coal can be mined at an average rate of 60 tons per hour; other materials also may be mined by the device.

"A Track-Laying Shuttle Car" was presented by J. W. Brauns, General Electric Company. The need for fast, efficient transfer of coal from the working face of the mine to the secondary haulage system has led to the development of a car capable of laying its own tracks, which makes it highly maneuverable. The car may be operated equally well in the forward or reverse directions.

Thomas R. Weichel, The Okonite Company, discussed the "Use and Application of Neoprene-Sheathed Cables in Mines." Neoprene has attained wide use on electric cable as a protective jacket because of its resistance to chemical agents and weathering, and because it will not support combustion. The many types of cords and cables with such covering were described, as were methods of suspension, installation, and termination.

"Mine-Trailing Cables" by Steve Bunish, Anaconda Wire and Cable Company, gave data on the construction, causes of damage, and maintenance of such cables. In the long run, the life of cable depends on the way in which the user treats it; excessive tension, mechanical damage, electrical overload, and poor joints and terminals are the main causes of damage. A table and photographs of damaged cable were presented.

A. H. Myles, Electric Controller and Manufacturing Company, discussed "A 2-Motor A-C Mine Hoist Control System." Control equipment for providing very slow stable speed for mine shaft and cable inspection and for cable reeving was described. The use of frequency-responsive relays to control acceleration, slow speed, and overspeed allow induction motors to be used.

One of the more interesting sessions was that devoted to general industry applications over which Jack Steelman, Jr., International Nickel Company, Inc., presided on Friday afternoon.

Three District papers were presented, the

Miss Vivien Kellems, president of the Kellems Company, was the featured speaker at the General Session. Shown here, left to right, are W. B. Morton, Vice-President, District 2; AIEE President Elgin B. Robertson; Miss Kellems; and William C. Marland, Governor of West Virginia

first, "Neoprene, the Versatile Rubber," being given by P. P. Murawski, E. I. du Pont de Nemours and Company. By means of motion pictures supplemented by demonstrations, the author showed how this new compound's properties are superior in many respects to other types of rubber.

G. H. Knapp, Civil Aeronautics Administration, described an instrument for finding short circuits and grounds in underground conductors, in his paper, "Audio Fault Finder for Cable." A 1,000-cycle signal is introduced into the faulty cable and this is detected by a portable audio-frequency amplifier with a loop input resonated at 1 kc and its output terminating in high-impedance headphones. When this detecting device is carried over the path of a cable, the tone is heard until the pickup coil is over the fault. The speaker demonstrated this action with a loudspeaker replacing the headphones.

The final paper, "Electricity Applied to Glass Melting," was given by J. H. Glaser, Dunbar Glass Company. After an introductory motion picture showing microphotographically the action of various chemicals in furnaces up to 4,000 degrees Fahrenheit, the speaker gave a brief history of the methods used in melting glass and the results obtained with direct resistance heating.

MEETING COMMITTEE

The success of this meeting was due to the efforts of the Meeting Committee whose chairman was R. H. Greame. H. K. Atkins was secretary; F. A. Leinbelger, treasurer; and R. H. Hively, administration and co-ordination. The chairmen of the committees were C. R. Stouch, arrangements; Mr. and Mrs. C. B. Talley, entertainment; G. W. Unangst, technical papers; P. M. Barlow, meetings and inspection trips; E. D. Knight, finance; H. L. Lindsey, advisory; and W. J. Hess and B. W. Whittington, cochairmen of publicity.

Scintillation Counter Program Will Stress Recent Advances

A Scintillation Counter Symposium under the sponsorship of the AIEE, Institute of Radio Engineers, Atomic Energy Commission, and the National Bureau of Standards will be held in Washington, D. C., on January 26–27, 1954. Four sessions are planned, covering energy spectrometry, cosmic-ray and high-energy particle measurements, scintillation counter applications, and phosphors and photomultipliers.

The program will include a group of invited papers and a limited number of short (15-minute) contributed papers. Those interested in presenting papers at the symposium are requested to submit the title and abstract for consideration to R. K. Swank, Chairman, Program Committee; Argonne National Laboratories, Chicago, Ill., by December 15, 1953.

Advance registration is required for attendance, and the registration fee is $2.00. Persons wishing to attend should forward their application and registration fee to H. O. Wyckoff, Chairman, Attendance Committee; National Bureau of Standards, Washington 25, D. C.

The program is designed, in so far as possible, to present the recent advances in scintillation counter technology. The design and performance of instruments and components will be considered. The application of the scintillation counter to the solution of both industrial and purely scientific problems will be discussed. For additional information, contact G. A. Morton, Chairman, Scintillation Counter Symposium Committee; RCA Laboratories, Princeton, N. J.

An outdoor courtyard dinner given for members of the San Francisco Section and their guests preceding their recent tour of the Pacific Electric Manufacturing Corporation's oil circuit breaker manufacturing facilities

San Francisco Section Tours Circuit Breaker Plant

The 1953–54 season's technical meeting series of the AIEE San Francisco (Calif.) Section was initiated on September 15, 1953, with a field trip to the Pacific Electric Manufacturing Corporation's oil circuit breaker plant in San Francisco. The tour of the plant facilities, which was taken by 430 members and guests, was preceded by a dinner given by the company for those attending.

The meeting following the dinner was opened by the chairman of the San Francisco Section, W. R. Johnson, and a welcome was extended to the AIEE by E. F. Sixtus, vice-president of the Pacific Corporation. Y. Tamir of the Palestine Electric Company was introduced as the guest coming the greatest distance. The company's founder and president, J. S. Thompson, also greeted the guests, and introduced R. W. Van Norden, who is recognized for his contributions to the development of the West's water and power facilities. Mr. Van Norden began his engineering career in 1896. He now maintains a consulting practice.

The inspection trip included operating demonstrations of various sizes of oil circuit breakers; the machine, foundry, pattern, iron working, and paint shops; and the engineering test laboratory. Colored motion pictures showing power system operation problems were presented to those awaiting a second session of the demonstrations.

This inspection tour was the first activity of the season of the Section's Technical Program Committee under the chairmanship of R. N. Keen, General Electric Company, with T. M. Googin, Consolidated Purchasing and Designing, Inc., as chairman of the Field Trip Subcommittee. The planning and arrangements for the evening were the responsibility of G. K. Schwind of the Pacific Electric Manufacturing Corporation.

Nuclear Engineering Conference Held at University of California

Some 300 persons, including representation from several European countries, attended the Conference on Nuclear Engineering held at the University of California, Berkeley, Calif., September 9–11, 1953. The conference was sponsored by the Berkeley and Los Angeles Branches and the Extension Division of the University of California with the co-operation of the AIEE, The American Society of Mechanical Engineers, American Institute of Chemical Engineers, American Society for Metals, and the American Society for Engineering Education, Committee on Atomic Energy Education. In line with its purpose of helping to advance the growth, stability, and value of the nuclear energy field, the conference offered a high-level technical program of contributed, unclassified, and declassified papers for persons concerned with the beneficial applications of atomic energy.

When the conference was being planned, it was recognized that there was a need for a program of unpublished papers on results of research and development work. First, it was felt that workers in nuclear engineering and allied fields deserved a more concerted opportunity than had been heretofore available for discussion of recent, nonclassified, research and development studies. The conference, though unclassified, was planned to provide a valuable occasion for exchange and stimulation of ideas among workers in these fields. Second, the considerable expenditures to date on nuclear energy have resulted, even under present legal and policy restrictions, in much unclassified and declassifiable engineering information, most of which was unpublished. The experience which this information represented was thought should be made more readily available for governmental and industrial personnel alike, thus serving to strengthen the economic base of the field and to encourage further technical development. Finally, a technical conference clearly provides unusual incentives for personnel to record the results of their work. Therefore, it was felt that this conference would complement the activities of the various technical societies, institutions, governmental agencies, and private industry involved in the field.

Based on these objectives, the program worked out by the Conference Committee under the chairmanship of R. A. Fayram, University of California, consisted of ten sessions on nine general subjects and three invited papers presented outside of the regular sessions. Session subjects were

Reactors: Power and Research
Equipment for Neutron Research
Nuclear Power Plant Economics
Kinematics, Instrumentation and Control
Materials
Chemical Processing and Heat Transfer
Radioactive Materials Handling
Accelerator Engineering
Uses of Isotopes and Nuclear Radiation

The papers dealt in detail with a diversity of topics under each of the subjects and reported on research and development results, designs of equipment, control and instrumentation, engineering problems, and economic studies. Invited papers were

"Wanted: A Single-Purpose Nuclear Power Program," George L. Weill, Consultant, Washington, D. C.

"Metals for Reactor-Core Construction," Henry A. Saller, Battelle Memorial Institute, Columbus, Ohio

"The Safety of Nuclear Reactors," Edward Teller, University of California, Berkeley, Calif.

All but two of the regular sessions papers (five in abstract form) and the first two of the invited papers have been published as the "Proceedings of the 1953 Conference on Nuclear Engineering." Copies are available for purchase by mail at the price of $7.50, plus California sales tax, from the California Book Company, 2310 Telegraph Avenue, Berkeley 4, Calif.

The eminent success of the conference led to the decision to make it an annual affair, and the next conference will be held at the University of California, Los Angeles, September 1954. Inquiries about the 1954 conference and its program should be addressed to T. J. Connelly, University of California, Los Angeles, Calif., the general conference chairman for 1954.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Television and Aural Broadcasting Systems (*C. E. Dean, Chairman; L. M. Rodgers, Vice-Chairman; R. K. Hellmann, Secretary*). The year's work of the committee was initiated at a meeting on September 10 when new members extending the representation of receiver makers and engineering school faculties were welcomed. Various interesting papers for presentation at the January Winter General Meeting were discussed. Of special importance is a paper in the field of color television describing the effect of signal amplitude in producing variations of the chrominance signal as a result of nonlinearity in equipment used satisfactorily for monochrome service. With the prospect of early introduction of color television broadcasting, this paper and others are expected to be very interesting and valuable to the membership.

General Applications Division

Committee on Land Transportation (*Jacob Stair, Jr., Chairman; P. H. Hatch, Vice-Chairman; G. M. Woods, Secretary*). Two sessions are planned for the Winter General Meeting to be held in New York, N. Y., January 18–24, 1954.

At a session on heavy electric traction, there will be one paper covering the economics of railway electrification, and several papers on electric locomotives and multiple-unit cars equipped with mercury-arc rectifiers, which permit the use of a high-voltage a-c source of energy and d-c traction motors. The presentation will include the effect of such apparatus on adjacent communication circuits and the means taken to mitigate undesirable influences. In view of the substantial number of electric locomotives and multiple-unit cars equipped in this manner which will be placed in service in the near future, these papers are especially timely.

At the diesel-electric traction session, the plans call for one paper of a general nature and several papers relating to means for reducing flashovers of traction motors and generators on diesel-electric locomotives, a problem that is concerning the railroads of the country.

Committee on Marine Transportation (*W. E. Jacobsen, Chairman; J. E. Jones, Vice-Chairman; W. N. Zippler, Secretary*). The Committee on Marine Transportation, in co-operation with the AIEE New York Section, will sponsor a marine session at the Winter General Meeting in New York. A total of four papers will be presented. Two of these papers will deal with the timely subject of nuclear power in the marine industry. Another will deal with diesel-electric drive, and the fourth will concern itself with electrical and mechanical engineering developments as applied to modern tankers.

Industry Division

Committee on Electric Welding (*E. J. Limpel, Chairman; J. F. Deffenbaugh, Vice-Chairman; R. J. Krieger, Secretary*). The Committee on Electric Welding has scheduled its Fourth Conference on Electric Welding for May 19–21, 1954, in Milwaukee, Wis. The committee tentatively has scheduled sessions on resistance welding, inert gas arc welding, fundamental arc research, instrumentation, and safety. In addition, a number of inspection trips to several Milwaukee industrial plants are planned. A. U. Welch of the General Electric Company will act as chairman of the Papers Committee. Anyone wishing to present a paper at this conference should contact Mr. Welch or one of the committee officers.

The Subcommittee on Fundamental Arc Research (L. P. Winsor, chairman) is presently engaged in classifying several hundred entries to complete a bibliography on high-pressure electric arcs. This bibliography will be published soon and offered for sale at a nominal cost through AIEE headquarters.

The Subcommittee on Instrumentation for Resistance Welding (C. R. Dixon, chairman) is presently engaged in defining the problems of measurements in resistance welding. Twelve variables are under consideration: current, voltage, power, power factor, force, time, motion, energy, resistance, capacitance, inductance, and temperature. In the future, the subcommittee plans to gather information regarding instrumentation presently available and make recommendations for developing new instrumentation in addition to making recommendations for standards on instruments for measuring resistance welding variables.

Power Division

Committee on System Engineering (*H. L. Harrington, Chairman; A. P. Hayward, Vice-Chairman; H. C. Otten, Secretary*). Following the round-table discussion in Chicago last spring on service continuity it was found that interest in the subject had developed to such a point that the committee decided that a technical session should be sponsored. Accordingly such a session is tentatively scheduled for the North Eastern District Meeting at Schenectady, N. Y., in 1954.

Due to the increasing interest in extra-high-voltage transmission, the committee has undertaken a study of this subject, particularly in its system planning and operation phases. Tentative plans are developing for presenting a technical session on the subject in the near future, possibly in co-operation with other committees with interests in other phases of the problem.

Studies are also underway in regard to the effect of low frequency on the performance and output of steam electric stations and means of relieving overloads on systems and areas.

Investigations of various methods of automatic load frequency control are continuing and a 2-session technical program on the subject is being planned for the 1954 Winter General Meeting. This will be a continuation and expansion of previously presented programs.

Other matters of particular interest to system operating engineers are under constant study including melting ice from transmission lines, effects of losses on economical system operation, interconnected systems energy accounting procedures, and other similar problems.

Committee on Transmission and Distribution (*F. V. Smith, Chairman; T. J. Brosnan, Vice-Chairman; J. T. Lusignan, Jr., Secretary*). The committee held a meeting at Atlantic City, N. J., in June attended by 49 members and guests. The five subcommittees have a long list of active projects, the more important of which are the following. *Capacitors:* Completion of a supplement to the "Bibliography on Power Capacitors 1925–1950"; continuation of studies on the effect of short-time overvoltages on capacitor life; a report on capacitor switching problems. *Distribution:* Studies of higher voltage primary supply; co-ordination of protection of distribution circuits. *General Systems:* A committee report on sleet-melting practices; further work on the characteristics of switching surges. *Lightning and Insulators:* Collection of material on impulse characteristics of insulators, wood, and air in series; methods of determining the number of insulators for various transmission voltages. *Towers, Poles, and Conductors:* Studies on the comparative merits of wood, steel, and aluminum supports for transmission lines; life, treatment, and loading of wood poles; practices with regard to broken conductors. A study also is being made of the matter of clearances for the higher voltages for use in connection with a revision of Part II of the National Electric Safety Code (American Standards Association Standard *C-2*) that is now under consideration.

Science and Electronics Division

Subcommittee on Dielectrics of the Basic Science's Committee (*L. J. Berberich, Chairman*). During the year a working group was formed within the subcommittee which has for its purpose the evaluation of thermal stability of insulating materials. The functions of this working group, which had its first session at the Summer Meeting, are (1) to sponsor conferences or technical paper sessions dealing with the general subject of evaluation of thermal stability of insulating materials, (2) to develop AIEE test codes for evaluating the thermal stability of insulating materials ranging from solids to liquids, and (3) to provide ultimately the basic information necessary for the rational revision of AIEE Standard Number *1*, which covers the classification of insulating materials and insulation temperature standards in general.

The subcommittee has had a meeting in conjunction with the National Research Council Conference on Insulation which was held at Pocono Manor, Pa., October 19–21.

Committee on Electronics (*H. C. Steiner, Chairman; J. D. Ryder, Vice-Chairman; D. G. Wilson, Secretary*). The Joint Subcommittee on Electronic Instruments has been transferred to the Committee on Instruments and Measurements. Rudolf Feldt has been designated as liaison representative from this committee and will continue as subcommittee chairman.

Education Subcommittee. Professor J. M. Cage reports that a symposium on "Educational Trends in Electronic Engineering" has been scheduled for the 1954 Winter General Meeting.

Liaison With High-Frequency and Electric Heating. J. P. Kinn, incoming chairman of the Induction and Dielectric Heating Subcommittee, reports that a conference on electric heating was held in Detroit, Mich., on May 26, and was well attended. A second separate conference on high-frequency heating is planned for the fall of 1954. In view of the increased interference from radio-frequency heating and other industrial electronic apparatus to established radio and television systems, the subcommittee has initiated a program involving the AIEE, Institute of Radio Engineers (IRE), and leading electronics magazines to locate competent people throughout the United States who are equipped to help solve interference problems and provide equipment certification in line with Federal Communications Commission regulations.

Electron Tubes Subcommittee (*R. E. Higgs*). The joint IRE-AIEE Conference on Tubes and Solid State Devices will be held in June 1954 at Stanford University. Mr. Whalley of the subcommittee has been appointed to work on the conference program. The working groups on small tubes for entertainment use and small tubes for industrial use have been combined and J. R. Steen is serving as chairman of the combined membership.

Semiconductor Device Subcommittee (*J. P. Jordan*). This subcommittee has been working jointly with the IRE subcommittee in the field of definitions and standardization of semiconductor devices. The actual work has been carried on by task forces dedicated to definitions and methods of test. Preliminary outlines of acceptable methods of test are expected to be completed this year and it is expected that they will be available for discussion early next year. The definitions work should be in final form by December and may be submitted for consideration by other interested bodies shortly after the first of the year. A session was held at the Summer General Meeting at which the line of thinking for many of the methods of test were discussed. Plans will be initiated shortly for a similar symposium on the definitions and methods of test in their final form next year.

AIEE PERSONALITIES.....

R. H. Tapscott (AM '18, F '29), chairman of the board, Consolidated Edison Company of New York, Inc., New York, N. Y., has retired after 36 years of service. Mr. Tapscott will continue to serve as a member of the board, to which he was first elected in 1937. Mr. Tapscott became chairman in 1949 after he had served 12 years as president. He was named chief executive officer in 1942, a post he relinquished early this year. Mr. Tapscott was born in Brooklyn, N. Y., and graduated from Union College in 1909. He came to New York Edison in 1917 as assistant chief electrical engineer, after having served since graduation with General Electric. He soon became chief electrical engineer, then vice-president. In 1932 he was assigned to the task of co-ordinating the engineering, construction, and operation of the several electrical companies then affiliated with the Consolidated Edison system. In 1937 he was elected president of Consolidated Edison. Mr. Tapscott is a trustee of Union College, a member of the Advisory Engineering Council of Princeton University, and has been awarded an honorary doctorate in commercial science by New York University. Mr. Tapscott has served as a director of the Institute (1930–34) and vice-president (1934–36) and on the following AIEE committees: Standards (1924–29); Electrical Machinery (1926–27); Power Transmission and Distribution (1926–28); Headquarters (1928–36, Chairman, 1928–33); Board of Examiners (1930–33); Edison Medal (1930–34); Finance (1931–36, Chairman, 1934–36); Co-ordination of Institute Activities (1934–36); and Institute Policy (1937–38).

F. R. Benedict (AM '40, M '47), assistant engineering manager for industrial products, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed staff engineering manager on the staff of H. E. Seim, vice-president and general manager of the Westinghouse Sturtevant Division and Air Conditioning Division at Hyde Park, Mass., and The Bryant Electric Company of Bridgeport, Conn. In his newly created position, Mr. Benedict will oversee and assist in the direction and co-ordination of the engineering and development of these divisions. Mr. Benedict joined Westinghouse in 1928 at East Pittsburgh, Pa., following graduation from Tri-State College with an electrical engineering degree. His first 10 years with the company were spent

R. H. Tapscott

F. R. Benedict

J. T. Blake

in high-voltage laboratory work and special studies on insulating materials. Following several other engineering assignments, including that of manager of engineering and service for the New England area, he was named manager of industry engineering at East Pittsburgh headquarters in 1945. In 1948 he became engineering manager for the Westinghouse Atomic Power Division. He returned to headquarters in 1952 as assistant engineering manager for industrial products at Pittsburgh, Pa. Mr. Benedict is a Director of the Institute and has served on the following AIEE committees: Chemical, Electrochemical and Electrothermal Applications (1946–52, Chairman, 1948–50); Industry Co-ordinating (1948–50); Standards (1947–51); Technical Program (1948–50); Publication (1949–53); Edison Medal (1951–53); Constitution and Bylaws (1951–53, Chairman, 1951–53); Research (1951–53); and Liaison Representative on Standards Committee (1951–53).

J. T. Blake (AM '50), research director, Simplex Wire and Cable Company, Cambridge, Mass., has been awarded the Charles Goodyear Gold Medal by the American Chemical Society. This is the highest honor in rubber chemistry, and the award was made to Dr. Blake for nearly 30 years' service to the rubber industry. It was as a result of Dr. Blake's researches that rubber-jacketed underground cables became feasible. It was he who developed low-water-absorption deproteinized rubber insulation. Dr. Blake did his undergraduate work at Tufts College and graduated in 1921 with a degree of bachelor of science in chemical engineering. In 1924 he earned a doctorate in organic chemistry from Massachusetts Institute of Technology. He also has taught at Tufts, Massachusetts Institute of Technology, and Northeastern University. During World War II, Dr. Blake served with the Office of the Rubber Director of the War Production Board and currently is a consultant to the Research and Development Board of the Department of Defense.

W. E. Shoupp (M '48), director of development, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the Westinghouse Order of Merit "for his outstanding organizational ability demonstrated in the fields of electronics and nuclear energy research and development, and particularly in the development of the first submarine atomic power plant; for his extremely wide range of technical knowledge and his ability to combine theoretical with practical considerations; and for his understanding of the problems of technical personnel and his maintenance of loyalty and enthusiam in the members of his organization." A native of Troy, Ohio, Dr. Shoupp was graduated from Miami University in 1931 with the degree of bachelor of arts in physics. He received a master of arts degree at the University of Illinois in 1933 and a doctor of philosophy degree in 1937. He joined Westinghouse as a research fellow in 1938 and, until he came to the Atomic Power Division in 1949, had held various posts at the Research Laboratories. Dr. Shoupp is serving on the AIEE Committee on Nucleonics (1949–53).

R. L. McCoy (AM '25, F '51), chief design engineer, Locke Department, General Electric Company, Baltimore, Md., has been appointed manager—product planning and product services, of the Locke Marketing Section. Born in Wellington, Ohio, December 31, 1900, Mr. McCoy received the degree of bachelor of science in electrical engineering from Case Institute of Technology in 1923. After graduation he joined the General Electric Testing Department and participated in the advanced engineering course. In 1924 he entered the Locke Engineering Section as assistant design engineer. He served successively as sales representative, sales engineer, and in 1935 was made chief design engineer. In this position he directed the activities of the Locke Design Engineering Unit and the Locke High Voltage and Mechanical Testing Laboratory. He has served as chairman of the Technical Committee High Voltage Insulator Section of National Electrical Manufacturers Association and as a member of the American War Standards Committee on Ceramic Insulating Materials and Ceramic Insulators. Mr. McCoy was chairman of the Maryland Section of the AIEE for 1949–50 and is a member of Eta Kappa Nu and Sigma Xi.

C. S. Purnell (AM '29, M '35), electric utility manager, Eastern District, Westinghouse Electric Corporation, New York, N. Y., has been named regional electric utility manager for the Northeastern Region. **F. G. Graf** (M '51), agency and construction manager, Eastern District, has been named agency and construction manager for the Northeastern Region, and **M. L. Gardner** (AM '40, F '51), engineering manager for the district engineering and service department, East Pittsburgh, Pa., has been named Northeastern Region engineering and service manager. The Northeastern Region includes the territory of the Eastern and New England Districts. Mr. Purnell is a Director of the Institute and has served as vice-president, District 3 (1950–52), and on the following AIEE committees: Sections (1943–53, Chairman, 1951–53); Headquarters (1948–50, Chairman, 1948–50); Edison Medal (1950–52); Finance (1950–53, Chairman, 1953); Executive (1951–52); and Planning and Co-ordination (1952–53).

R. C. Hanna (AM '39, M '52), sales manager, Fractional Horsepower Motor Division, General Electric Company, Fort Wayne, Ind., has been appointed manager of marketing, Component Products Division. Mr. Hanna joined General Electric in 1929 after graduation from Virginia Military Institute with a bachelor of science degree in electrical engineering. Transferred to Fort Wayne in 1931, he was assigned to the engineering division of the Fractional Horsepower Motor Division. In 1933 he entered sales where he worked on application engineering and sales problems. During 1941, Mr. Hanna received special assignments related to motors for the armed services, and in 1942 he was loaned to the War Production Board first for a 3-month special assignment and then in 1943 as chief of the fractional horsepower motor section of the board. He returned to General Electric in 1945 and was named assistant to the sales manager of the Fractional Horsepower Motor Division. Two years later he was appointed assistant manager of sales for the department and in 1950 became manager of sales.

J. W. Simpson (AM '43, M '49), assistant division manager, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the Westinghouse Order of Merit for "his outstanding work in meeting the needs of the United States Navy for switchboards during World War II; for his talented contribution to the technical organization of the Atomic Power Division; for his co-ordination and prosecution of the manifold technical details connected with the design and construction of the first submarine atomic power plant." Mr. Simpson was born in Glenn Springs, S. C., and after enlisting in the United States Marine Corps was appointed to the United States Naval Academy. He was graduated with a bachelor of science degree in engineering in 1937 and the same year joined Westinghouse in the Graduate Student Course. He held various posts in the Switchgear Division between 1938 and 1949. During that time he was granted a 2-year leave of absence to work at the Oak Ridge (Tenn.) National Laboratory. He was named assistant manager of engineering, Atomic Power Division, in 1949.

P. N. Ross (AM '45), manager, reactor department, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the Westinghouse Order of Merit "for his broad understanding and clear expression of nuclear power problems; for his contributions toward the development of the research department of the Atomic Power Division; and for his successful guidance in the completion of the nuclear core and its control drive mechanism for the first submarine atomic power plant." Mr. Ross was born in Boston, Mass., and received his bachelor of science and master of science degrees from Harvard University. He joined Westinghouse as a member of the Graduate Student Course in 1939. A year later he was named a junior engineer of the central station department. After spending 4 years with the United States Navy Department he returned to his former post at Westinghouse. From 1946 to 1948, he was a technical assistant, Power Pile Division, Oak Ridge (Tenn.) National Laboratory. He joined the Atomic Power Division as assistant director of research in 1948 and was named manager of general engineering in 1951. Mr. Ross is serving on the AIEE Committee on Nucleonics (1949–53).

R. C. Cunningham (AM '42), manager, power plant department, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the Westinghouse Order of Merit for "his careful guidance of the development of the control system for the first submarine atomic power plant; for his skillful co-ordination of design, erection, and test operations at widely scattered locations, and for his leadership in the engineering design of nuclear power plants." Mr. Cunningham was born in Gilman City, Mo., and was graduated from the University of Missouri in 1936. That same year he joined the Westinghouse Graduate Student Course. He worked in the Switchgear Division until 1943 when he joined the government's Manhattan Project. From 1946 to 1949 he was associated with the Motor and Control Division at Buffalo, N. Y. He joined the Atomic Power Division in 1949.

R. C. Cheek (AM '42, M '47), assistant division sales manager, Electronics Division, Westinghouse Electric Corporation, Baltimore, Md., has been appointed assistant manager of engineering for the division. A native of Charleston, S. C., he joined Westinghouse in Pittsburgh, Pa., in 1939 following his graduation from Georgia Institute of Technology. From 1942 until his transfer to Baltimore in 1951, Mr. Cheek acted first as a consultant on power system problems for Southeastern District utilities, and finally as a specialist in carrier and microwave applications for the country as a whole. Mr. Cheek is a member of the Institute of Radio Engineers and was named "outstanding young electrical engineer" by Eta Kappa Nu in 1949. He is serving on the AIEE Committee on Carrier Current (1950–53).

C. P. Hayes (AM '41), General Electric Company, Louisville, Ky., has been appointed general manager of the Ballast Department with headquarters in Danville, Ill. **G. C. Harvey** (AM '33, M '44), engineer, Ballast Division, Fort Wayne, Ind., has been named manager—engineering of the Ballast Department; and **E. J. Thomas** (AM '34, F '51), engineering manager, Specialty Transformer and Ballast Department, has been appointed manager—engineering, Specialty Transformer Department, Fort Wayne. Mr. Hayes, a native of Asheville, N. C., was graduated from the University of North Carolina in 1932 with a bachelor of science degree in electrical engineering. That same year he joined the General Electric Test Course at Bloomfield, N. J., and after completing the advanced engineering program in 1935 was transferred to the Specialty Transformer and Ballast Department at Fort Wayne as a design engineer. He served in various capacities in that department and the Fractional Horsepower Motor Department until 1950 when he was moved to the Small Apparatus Division headquarters at Lynn, Mass. In 1950 he was appointed manufacturing engineer in the Manufacturing Services Division before being assigned to the marketing organization of the Major Appliance Division in Louisville. Mr. Hayes has served on the AIEE Committee on the Production and Application of Light (1947–50). Mr. Harvey has served on the Institute Committees on Membership (1947–48) and the Production and Application of Light (1950–53).

J. A. Dewhurst (AM '11, Member for Life), supervising senior engineer, Ford, Bacon and Davis, Inc., New York, N. Y., retired July 31, 1953. Mr. Dewhurst had been with Ford, Bacon and Davis for 18 years. Prior to that he was with McGraw-Hill Publishing Company, New York, N. Y., and Day and Zimmermann, Philadelphia, Pa. After graduation from the University of Washington in 1909, he joined the General Electric Company, then, after 6 years, went to the Twin City Rapid Transit Company, and then to Day and Zimmermann.

E. S. Rehagen (AM '36, M '42), manager, St. Louis (Mo.) branch office, Westinghouse Electric Corporation, has been named manager of the branch office in Cleveland, Ohio. Mr. Rehagen graduated from Rockhurst College in 1924 with a bachelor of arts degree and attended the University of Missouri, where he received a bachelor of science degree in engineering. Mr. Rehagen began his career with Westinghouse in 1928 as a graduate student. He served as application engineer in the company's Southwestern District and as supervisor of the Westinghouse electric utility department in St. Louis. In January 1953 he was named manager of the newly created St. Louis branch office.

L. E. Merrow (M '36), executive assistant, Rockland Light and Power Company, Nyack, N. Y., has been elected a vice-president. Mr. Merrow, a graduate of the University of Maine with a bachelor of science degree in electrical engineering, attended the General Electric Test Course. He was associated with Cumberland County Power and Light Company from 1921 to 1923, and was assistant to the manager of the Montpelier and Barre (Vt.) Light and Power Company from 1923 to 1930. Mr. Merrow then served as an engineer with New England Public Service Company before joining Rockland Light and Power as superintendent of electrical production in 1931. He was appointed executive assistant of the company in 1935. Mr. Merrow is a licensed professional engineer in New York.

A. L. Thurman (AM '38, M '45), manager, Plastics and Rubber Machinery Division, Aetna-Standard Engineering Company, Warren, Ohio, has joined Mannesmann-Meer Engineering and Construction Company, Easton, Pa., as executive vice-president. Mr. Thurman comes to Mannesmann-Meer after 7 years of mill machinery experience with Aetna-Standard. Prior to that time he was with the General Electric Company for over 8 years, the last 5 years of that period having been spent as a steel mill application engineer in the Steel Mill Division.

Yun Chang (AM '53), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been assigned to the research laboratory staff of the company's Norwood (Ohio) works. Mr. Chang received his masters degree in 1952 from the Polytechnic Institute of Brooklyn. He had previously received his bachelors degree in electrical engineering from National Tung-Chi University. Before coming to this country, Mr. Chang was successively a senior electrical engineer with the Fooya Electric Works, Hongkong, and a radio engineer with the Civil Aeronautics Administration, Shanghai.

W. F. Rauber (M '45), special representative, General Electric Apparatus Group, Washington, D. C., has been appointed manager of the company's apparatus sales office, Buffalo, N. Y. Mr. Rauber is a graduate of the University of Notre Dame and started with General Electric as a student engineer in Schenectady, N. Y. From 1928 to 1936, Mr. Rauber was a switchgear specialist in the Cincinnati and Cleveland, Ohio, offices. Later he was with the company's Philadelphia (Pa.) works and by 1940 was in charge of sales of outdoor circuit breakers. In 1948 he became assistant manager of sales in the Switchgear Department and a year later manager of sales. Since 1951 he has been a special representative in Washington.

E. G. Horton (AM '41), manager, New Haven (Conn.) office, Westinghouse Electric Corporation, has been appointed manager of the Connecticut Valley District, with headquarters at Hartford, Conn. **H. E. Dralle** (AM '41), engineering and service manager, Eastern District, New York, N. Y., has been appointed manager of the New York City District; and **H. B. Vidal** (AM '24, M '34), manager, Buffalo (N. Y.) office, has been named manager of the New York State District with headquarters in Buffalo. Mr. Dralle has served on the AIEE Committee on Land Transportation (1948–49); and Mr. Vidal has served on the Committee on Electrochemistry and Electrometallurgy (1932–34).

G. K. Haspel (M '31), automatic telephone engineer, British Columbia Telephone Company, Vancouver, British Columbia, Canada, retired recently after 47 years with the telephone industry. Born in Indiana, Mr. Haspel began his telephone career while still in high school. For 10 years he worked for Automatic Electric Company of Chicago, Ill., engineering automatic telephone installations for Australia, New Zealand, Japan, Germany, Belgium, and parts of South America. He came to Vancouver in 1929 and engineered dial telephone equipment for every automatic installation in British Columbia Telephone Company territory. He is a past president of Chapter 53, Telephone Pioneers of America, and a past chairman of the Vancouver Section of the AIEE.

O. W. Briden (AM '27), regional construction engineer, Rural Electrification Administration, Washington, D. C., has been appointed director, North Central Electric Area. **W. M. Edmunds** (AM '31, M '47), assistant chief, engineering division, has been named chief, Northern Region, of the electric program. **J. B. McCurley** (AM '30, F '50), power division, has been appointed chief, Electric Operations Division. **J. E. O'Brien** (AM '29, F '51), chief, technical standards division, has been named chief, Electric Engineering Division. Mr. Edmunds has served on the Institute Committee on Transformers (1950–51) and Mr. O'Brien has served on the following AIEE committees: Communication (1941–42); Transmission and Distribution (1948–53); and Standards (1948–53).

R. L. Westbee (AM '36), general manager, Electrical Insulation and Sound Recording Tape Division, Minnesota Mining and Manufacturing Company, St. Paul, has been elected a vice-president of the company. Mr. Westbee will head the newly created Electrical Products Division. The new division includes the Electrical Insulation and Sound Recording Tape Division, the Irvington Varnish and Insulator Division, and the American Lava Corporation. Mr. Westbee joined Minnesota Mining and Manufacturing as a technician in 1933, shortly after graduation from the University of Minnesota. In 1940 he was assigned to electrical tape engineering. He was named sales manager of the Electrical Insulation and Sound Recording Tape Division in 1944 and has been general manager since 1948.

E. W. Marlowe (AM '47), supervising engineer, Research Section, Union Switch and Signal Company, Swissvale, Pa., has been appointed section engineer, Air Traffic Control and Navigation. Born in Lawrenceburg, Ind., Mr. Marlowe received a bachelor of science degree in chemistry from the University of Chicago in 1934. After positions with the Prest-O-Lite Battery Company and Universal Oil Products Company, he worked as an electronic engineer during World War II for both the Naval Ordnance Laboratory, Washington, D. C., and the University of California, Los Alamos, N. Mex. In 1945 he joined Union Switch and Signal as a staff engineer, Research Department. He was named supervising engineer, Research Section, in August 1952. Mr. Marlowe is a member of the Institute of Radio Engineers and the Association for Computing Machinery.

L. K. Hedding (AM '45), supervisor, rectifier engineering, Union Switch and Signal Company, Swissvale, Pa., has been appointed section engineer, electrical products. Born in Stanton, Mich., Mr. Hedding received a bachelor of science degree in electrical engineering from the University of Michigan in 1930 and in 1949 a master of science degree from the University of Pittsburgh. Mr. Hedding joined Union Switch and Signal in 1930 as an apprentice engineer. He subsequently served as a design engineer, rectifiers and transformers; supervisor, rectifier research; and supervisor, rectifier engineering. Mr. Hedding is a member of the Signal Section, Association of American Railroads, and the Pennsylvania and National Societies of Professional Engineers. He is serving on the AIEE Committee on Metallic Rectifiers (1950–53).

L. M. Hovey (AM '45), electrical engineer, Winnipeg Electric Company, Winnipeg, Manitoba, Canada, has taken the position of manager of the system engineering and planning division with the company. Mr. Hovey entered Winnipeg Electric Company service in 1925 after employment as draftsman and machinist with Butterfield and Company, Rock Island, Quebec, Canada. He was born at Rock Island, Quebec, July 8, 1902, and was educated at Stanstead College School and graduated from McGill University with a bachelor of science degree in electrical engineering. He has been associated with the Winnipeg Electric Company as a draftsman, then assistant engineer, and most recently, electrical engineer. Mr. Hovey is a member of the Association of Professional Engineers of the Province of Manitoba and the Engineering Institute of Canada.

F. C. Vose (M '48), lieutenant colonel, United States Air Force, New York, N. Y., has returned to the Locke Department, General Electric Company, Baltimore, Md., as chief design engineer. Mr. Vose was formerly assistant to the chief design engineer and prior to that served as test engineer and design engineer in other departments of General Electric.

W. E. Pearson (AM '52), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been assigned to the Switchgear Department as an assistant engineer. A 1951 graduate electrical engineer of the University of Missouri, Mr. Pearson joined Allis-Chalmers the same year. He recently completed the company's training course for graduate engineers.

W. R. G. Baker (AM '19, F '47), vice-president, General Electric Company, Syracuse, N. Y., has been awarded the 1953 Medal of Honor by the Radio-Television Manufacturers Association for his outstanding contributions to the advancement of the radio-television-electronics industry. Dr. Baker was presented the Medal of Honor during the Association's annual convention.

OBITUARY • • • •

Roland Guyer Porter (AM '25, M '35, F '44), professor and head of the electrical engineering department, Northeastern University, Boston, Mass., died September 2, 1953. Professor Porter was born in South Norwalk, Conn., June 9, 1894, and graduated from Northeastern University in 1918. After graduation he served as an ensign in the United States Naval Reserve. Upon leaving the service in 1919, he was appointed instructor of electrical engineering at Northeastern University. Four years later he was promoted to assistant professor and in 1929 to associate professor of electrical engineering. During this period he studied at the Graduate School of Engineering, Harvard University, receiving his master of science degree in 1932. He was appointed professor of electrical engineering and chairman of the electrical engineering department in 1937. Mr. Porter was a member of Tau Beta Pi, Eta Kappa Nu, American Society for Engineering Education, Institute of Radio Engineers, and Illuminating Engineering Society. He was a past chairman of the Boston Section of the AIEE, had been Student Branch Counsellor at Northeastern since 1937, and had served as chairman of District 1 Student Branch Counsellors. He had served on the AIEE Committees on Education and Student Branches.

Oliver Claggett Traver (AM '10, M '20, F '43, Member for Life), retired, died September 10, 1953. Mr. Traver, former designing engineer, relays and switchgear devices, and patent engineer, Switchgear, Department, General Electric Company, had retired in 1946 after more than 38 years' service with the company. Mr. Traver was born at Glen Gardner, N. J., and graduated from Stevens Institute of Technology in 1907. He began his career with General Electric in 1908 at Schenectady, N. Y., and later served there as a design engineer on switchgear devices, air circuit breakers, and relays from 1923 to 1928. He was transferred to Philadelphia, Pa., as designing engineer on relays in 1928. He was appointed patent engineer in 1935. Mr. Traver had been granted 70 United States patents for his inventions. He was a member of Tau Beta Pi and the Franklin Institute. He was a past chairman of the Philadelphia Section of the AIEE and had served on the Committee on Protective Devices.

Charles Justus Garrahan (AM '46), assistant professor of electrical engineering, Swarthmore College, Swarthmore, Pa., died August 10, 1953. Professor Garrahan was born December 24, 1908, in Philadelphia, Pa., and received his bachelor of science degree in electrical engineering from the University of Pennsylvania in 1930 and his masters degree in 1931. From 1931 to 1933 Mr. Garrahan was a research associate at the Moore School of Electrical Engineering X-Ray Laboratory, and then was a Johnson Fellow in Biophysics at the University of Pennsylvania and an X-ray physicist at University Hospital. From 1937 to 1941 he was associated with the Picker X-Ray Corporation and the Westinghouse X-Ray Company. He joined the Swarthmore faculty in 1941. Mr. Garrahan was a member of Sigma Xi.

James Walter Bishop (AM '23, M '42, Member for Life), Detroit, Mich., died September 5, 1953. Mr. Bishop was a director of the Edison Institute at Greenfield Village, Mich. Mr. Bishop was born in Detroit, Mich., March 1, 1875. From 1890 to 1904 he was with the Edison Illuminating Company of Detroit. In 1904 he became superintendent of substations for the Detroit Edison Company, a position he held until 1927 when he was loaned to Henry Ford to collect antique electric equipment. He continued with Mr. Ford and later for the Edison Institute until his illness 3 years ago.

Percy Howard Powell (AM '95, Member for Life), mechanical engineer and electrical engineer, Wallingford, Conn., died May 14, 1953. Mr. Powell was born November 20, 1868, in Hempstead, N. Y., and graduated from Cornell University in 1895. Mr. Powell was engaged in the metal manufacturing business in Bridgeport, Conn., for many years. He was a member of the American Association for the Advancement of Science and the Cornell Society of Engineers.

MEMBERSHIP . . .

Recommended for Transfer

The Board of Examiners at its meeting of September 17, 1953, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Ahmed, W., professor & head elec. engg. dept., Engineering College, Dacca, East Pakistan
Austin, H. C., asst. chief, elec. engg. div., Southern California Edison Co., Los Angeles, Calif.
Baker, F. J., general supt., The Home Tel. & Tel. Co., Fort Wayne, Ind.
Bennett, W. R., design engineer, Westinghouse Electric Corp., Lima, Ohio
Betz, L. G., division meter engineer, Public Service Electric & Gas Co., Hackensack, N. J.
Biesemeier, K. W., asst. electrical engineer, Modesto Irrigation District, Modesto, Calif.
Binder, D., electrical project engineer, Philco Corp., Philadelphia, Pa.
Blumenauer, C. E., electrical engineer, United States Rubber Co., Chicopee Falls, Mass.
Bratu, N., electrical design engineer, Bodine Electric Co., Chicago, Ill.
Brittain, G. H., assistant supervisor, Armour Research Foundation, Chicago, Ill.
Brown, M. T., associate electrical engineer, City Engineers Office, Detroit, Mich.
Buendia, L. A., designer, Consolidated Edison Co. of New York, Inc., New York, N. Y.
Cardwell, L. H., operating division head, Dallas Power & Light Co., Dallas, Tex.
Chunn, C. B., administrative assistant, Southwestern Public Service Co., Amarillo, Tex.
Cunningham, B. T., electrical engineer, Chemical Construction Corp., New York, N. Y.
Curtis, C. L., engineer, U. S. Bureau of Reclamation, Billings, Mont.
Curtis, T. E., supervisor, North American Aviation, Inc., Downey, Calif.
Dilts, I. J., Jr., section engineer, General Electric Co., Lynn, Mass.
Dobson, D. R., engineer, Stackpole Carbon Co., East Pittsburgh, Pa.
Drummond, B. J., plant engineer, Detroit Steel Products Co., Detroit, Mich.
Drummond, J. W., general superintendent, The Detroit Edison Co., Detroit, Mich.
Dusina, L., electrical project engineer, Carbide & Carbon Chemicals Co., Oak Ridge, Tenn.
Elliott, C. H., electrical superintendent, Kaiser Aluminum & Chemical Corp., Chalmette, La.
Elton, M. B., assistant chief, electrical design unit, Bonneville Power Administration, Portland, Oreg.
Fallon, J. L., electrical engineer, U. S. Bureau of Reclamation, Washington, D. C.
Ferber, A. H., electrical engineer, Ebasco Services Inc., New York, N. Y.
Fouche, W. L., assistant district electrical engineer, Mene Grande Oil Co., Venezuela, S. A.
Frank, S. B., engineering representative, James R. Kearney Corp., St. Louis, Mo.
Garbellano, D. W., engineer, radiation laboratory, University of California, Berkeley, Calif.
Genthner, H. J., asst. supt., electric station maintainence, Rochester Gas & Electric Corp., Rochester, N. Y.
Gervais, W. A., engineer, General Electric Co., Schenectady, N. Y.
Grosser, E. H., Jr., supervising design engineer, Commonwealth Edison Co., Chicago, Ill.
Hammerquist, R. C., electrical engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.
Harry, H. E., unit manager, RCA Victor Div., Radio Corporation of America, Camden, N. J.
Hawley, C. L., chief system operator, Omaha Public Power District, Omaha, Nebr.
Hengy, G. C., owner, Geo. C. Hengy & Co., Consulting Engineers, 228 N. Market St., Shreveport, La.
Hermont, A. J., geophysicist, Shell Development Co., Houston, Tex.
Hopkin, A. M., asst. professor, electrical engineering dept., Northwestern University, Evanston, Ill.
Jones, D. W., Jr., electrical engineer, General Electric Co., Schenectady, N. Y.
Jones, W. C., distribution engineer, Nashville Electric Service, Nashville, Tenn.
King, L. L., plant personnel supervisor, Southwestern Bell Telephone Co., Oklahoma City, Okla.
Klyne, J. A., electrical engineer, Cleveland Electric Illuminating Co., Cleveland, Ohio
Knapp, G. W., manager, paper & textile engg. unit, General Electric Co., Schenectady, N. Y.
Koerner, C. T., staff engineer, The Pacific Tel. & Tel. Co., Los Angeles, Calif.
Koskos, P., engineer in charge, Sylvania Electric Products, Inc., Kew Gardens, N. Y.
Kuhnel, A. H., division engineer, The Austin Co., New York, N. Y.
Lea, L. L., distribution engineer, Central Power & Light Co., Pharr, Tex.
Loftin, A. D., partner, Tynes & Loftin, 345 Korber Bldg., Albuquerque, N. Mex.
Love, H. B., chief, electrical bureau, City of Detroit, Detroit, Mich.
Lukey, M. E., administrative engineer, Commonwealth Edison Co., Chicago, Ill.
Major, F. H., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Manning, E. W., product engineer, General Electric Co., Pittsfield, Mass.
McCosh, R. E., design engineer, Pacific Power & Light Co., Portland, Oreg.
Mead, G. E., electrical engineer, Civil Aeronautics Administration, Seattle, Wash.
Michaels, E. L., supervisor, Consolidated Vultee Aircraft Corp., Pomona, Calif.
Miller, J. A., district engineer, Haughton Elevator Co., Philadelphia, Pa.
Mollenhauer, A. A., relay engineer, City Service Board, San Antonio, Tex.
Morris, W. C., electrical engineer, Rural Electrification Administration, Washington, D. C.
Murphy, T. H., transportation service supervisor, Westinghouse Electric Corp., Pittsburgh, Pa.
Nearing, H. H., engineer, Rochester Gas & Electric Co., Rochester, N. Y.
Nuce, H. R., Jr., consulting & application electrical engineer, Westinghouse Electric Corp., Atlanta, Ga.
Oliver, F. J., editor, *Electrical Manufacturing*, Gage Publishing Co., New York, N. Y.
Polich, A. L., sales manager, General Electric Supply Co., Portland, Oreg.
Powell, J. W., chief engineer, The Pacific Tel. & Tel. Co., San Francisco, Calif.
Pullen, T. F., Veterans' Administration Hospital, Kerrville, Tex.
Quader, S. A., chief engineer, Hyderabad State Electricity Dept., Hyderabad, Deccan, India
Ragland, J. R., chief electrical engineer, H. N. Roberts & Associates, Consulting Engineers, Lubbock, Tex.
Remaly, H. A., engineer, General Electric Co., Richland, Wash.
Rhodes, J H., electrical field supervisor, Giffels & Vallet, Inc., Detroit, Mich.
Risley, M. I., staff transmission engineer, Northwestern Bell Telephone Co., Omaha, Nebr.
Ritchie, J. S., project engineer, Foothill Electric Corp., Richland, Wash.
Roadstrum, W. H., asst. professor of electronics, U. S. Naval Postgraduate School, Monterey, Calif.
Rogers, S., engineering supervisor, Consolidated Vultee Aircraft Corp., San Diego, Calif.
Scholl, R. A., industrial power engineer, Public Service Co. of Indiana, Inc., Kokomo, Ind.
Shaad, D. E., electrical engineer, Lutz & May, Consulting Engineers, 1009 Baltimore, Kansas City, Mo.
Shafer, E., Jr., assistant plant manager, Southwestern Public Service Co., Carlsbad, N. Mex.
Sims, V. R., electrical engineer, The Emerson Electric Mfg. Co., St. Louis, Mo.
Skitek, G. G., associate professor of electrical engineering, Missouri School of Mines, Rolla, Mo.
Smith, C. A., staff engineer, Chief Engineers' Office, Pacific Tel. & Tel. Co., San Francisco, Calif.
Smith, N. D., field engineer, Hanford project, Chas. T. Main, Inc., Richland, Wash.
Sparlin, B. J., engineer, radio interference laboratory, Westinghouse Electric Corp., East Pittsburgh, Pa.
Stein, J. J., general superintendent, PUD, Grays Harbor County, Aberdeen, Wash.
Steward, J. F., equipment engineer, The Southern New England Telephone Co., New Haven, Conn.
Stewart, M B., retired, 1630 Golden Hill Terrace, El Paso, Tex.
Takken, F. R., consulting engineer, G. M. Simsonson, 507 Howard St., San Francisco, Calif.
Theleen, D. J., sales engineer, General Electric Co., Davenport, Iowa
Towhey, H. M., area manager, Westinghouse Electric Corp., Philadelphia, Pa.
Treadwell, M. E., engineer, Michigan Bell Telephone Co., Detroit, Mich.
Ulm, R. W., superintendent, engineering dept., Carbide & Carbon Chemicals Co., Oak Ridge, Tenn.
Van Auken, M. E., electrical engineer, Consumers Power Co., Jackson, Mich.
Vassar, R. L., design engineer, General Electric Co., West Lynn, Mass.
Waggoner, W. M., electrical engineer, U. S. Bureau of Reclamation, Denver, Colo.
Walker, J. R., chief engineer, Wayne Engineering Research Institute, Detroit, Mich.
Walker, L. G., chief engineer, Motorola, Inc., Chicago, Ill.
Weedmark, N. J., assistant to electrical superintendent, The International Nickel Co., Copper Cliff, Ontario, Canada
Weins, J. F., senior associate electrical engineer, public works dept., City of Detroit, Mich.
Wier, W. E., electronics material officer, U. S. Navy, Great Lakes, Ill.
Wilson, G. P., chief electrical engineer, Continental Carbon Co., Amarillo, Tex.
Wilson, P. H., supervisor, aircraft gyroscope engineering, General Electric Co., Lynn, Mass.
Wylie, D. L., communication engineer, Bonneville Power Administration, Portland, Oreg.
Young, L., electrical engineer, Ebasco International Corp., New York, N. Y.
Zavera, M., assembly engineer, General Electric Co., Seattle, Wash.

102 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before November 25, 1953, or January 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Broacha, R. H., Tata Loco. & Engg. Co. Ltd., Jamshedpur, India
Klein, R. G., Manitowoc Shipbuilding, Inc., Manitowoc, Wis.
Myers, J. J., Automatic Elec. Co., Chicago, Ill.
Palmer, J. S. (re-election), Kansas City Power & Light Co., Kansas City, Mo.
Richards, A. V. (of Consolidated Diamond Mines of S.W.A., Oranjemund, South West Africa), 216 Balmoral Ave., Toronto, Ontario, Canada
Young, J., Jr., Ford Instrument Co., Div. of Sperry Corp., Long Island City, N. Y.

6 to grade of Member

AIEE Section and Student Branch Meetings—1952-1953

Table I. Section Membership, August 1953; Section Meetings During Year Ending April 30, 1953

Section	AIEE Members August 1953	Number of Meetings	Total Number of Meetings
Akron	206	1	1
Alabama	281	9	
Subsection: Mobile-Pensacola		7	16
Arizona	227	9	
Group: Technical		11	20
Arkansas	159	10	
Groups: Pine Bluff Technical		2	
Communications and Electronics		1	
Subsection: Northwest Arkansas		9	22
Arrowhead	76	9	9
Beaumont	127	8	
Group: Technical		4	
Subsection: Lake Charles		10	22
Boston	1,130	7	
Groups: Basic Sciences		1	
Communications		1	
Electronics		1	
Industrial Power Systems		2	
Instruments and Measurements		1	
Insulation		2	
Power Generation		2	
Power Systems Engineering		3	
Subsection: New Hampshire		4	
Joint Meetings: Basic Sciences and Communications Groups		2	
Instruments and Measurements and Electronics Groups		1	27

Table I (continued). Section Membership, August 1953; Section Meetings During Year Ending April 30, 1953

Section	AIEE Members August 1953	Number of Meetings	Total Number of Meetings
Canton	123	9	
Groups: Management Discussion		3	
Transistor Discussion		2	14
Central Illinois	158	9	9
Central Indiana	379	9	9
Chicago	2,119	4	
Groups: Basic Sciences		4	
Communications		4	
Electronics		5	
Industrial		5	
Power		5	27
Cincinnati	359	13	13
Cleveland	973	10	
Groups: Basic Sciences		4	
Communications and Electronics		3	
Electrical Construction		4	
Instruments and Measurements		2	
Motors and Control		4	
Power Generation and Distribution		3	30
Columbus	222	12	
Subsection: Zanesville		11	23
Connecticut	704	8	
Groups: Communications		3	
Electrical Controls and Measurements		3	
Electric Power Generation, Transmission, and Distribution		3	
Industrial Electronics		3	
Industrial Power Applications		4	24
Corpus Christi	86	10	10
Dayton	429	4	
Groups: Aeronautics		3	
Electronics		2	
Motors and Controls		4	
Power		3	
Subsection: Lima		7	
Joint Meetings: Section and Motors and Controls Group		1	
Section and Power Group		1	
Section and Electronics Group		1	
Section and Aeronautics Group		1	27
Delaware Bay	160	10	
Group: Discussion		3	13
Denver	491	12	
Groups: Communications and Electronics		3	
Electric Equipment		5	
Power Systems		5	
Subsections: Black Hills		5	
Casper (Wyo.)		5	35
East Tennessee	384	19	
Groups: Chattanooga Technical		7	
Knoxville Technical		7	
Subsections: Huntsville		2	
Tullahoma		2	37
El Paso	120	14	
Subsection: Pecos Valley		4	18
Erie	167	14	
Subsection: Ridgway		3	
Joint Meetings: Section and Ridgway Subsection		1	18
Fort Wayne	228	9	9
Georgia	338	10	
Subsection: Savannah		9	19
Houston	351	9	
Groups: Communication		2	
Industrial Applications		1	
Subsection: Freeport		6	18
Illinois Valley	85	10	
Group: Technical		5	15
Iowa	244	12	
Subsection: Quad-Cities		8	20
Ithaca	349	8	
Subsections: Binghamton Area		4	
Binghamton Area Discussion Group		1	13
Jacksonville	81	5	5
Kansas City	400	14	
Groups: Technical Discussion		7	
Communications		4	
Power		6	31
Lehigh Valley	484	2	
Groups: Technical		8	
Discussion		14	24
Los Angeles	2,115	8	
Groups: Aircraft		6	
Electronics		6	
Power		7	
Subsection: Boulder City		9	36
Louisville	222	8	
Subsection: Lexington		7	15
Lynn	383	21	21
Madison	102	10	10
Mansfield	104	8	8
Maryland	848	10	
Groups: Communications		4	
Industrial Electronics		3	
Power		2	
Subsections: Eastern Shore		8	
Lancaster-York		6	33
Memphis	121	10	10
Mexico	192	11	11
Miami	154	13	13
Michigan	1,129	7	
Groups: Communications		1	
Industrial Power		1	
Industry		4	
Instruments and Measurements		1	
Power		2	
Science and Electronics		4	
Welding		1	
Subsection: West Michigan		8	29
Milwaukee	940	9	
Groups: Basic Science		1	
Electric Machinery		2	
Electronics		1	
Power Application and Control		2	
Transmission and Distribution		3	
Subsections: Fox River Valley		10	
Racine-Kenosha		7	
Joint Meetings: Basic Science and Electric Machinery Groups		1	
Basic Science and Electronics Groups		1	37
Minnesota	468	10	
Group: Power		1	
Subsection: Red River Valley		8	19
Mississippi	93	8	
Groups: Discussion		2	
Technical		1	11
Mobile-Pensacola	110	3	3
Montana	127	9	
Subsection: Billings		9	18
Montreal	485	8	
Groups: Discussion		1	
Technical		7	
Subsection: St. Maurice Valley		6	22
Nashville	81	8	8
Nebraska	191	11	11
New Orleans	296	10	
Group: Technical		1	
Subsection: Baton Rouge		6	
Joint Meetings: Section and Baton Rouge Subsection		1	18
New York	5,990	2	
Groups: Basic Science		3	
Communication		6	
Illumination		4	
Power and Industrial		14	
Transportation		4	
Subsections: Hudson Valley		5	
New Jersey		7	
Joint Meetings: Basic Science and Communications Groups		2	
Communication and Transportation Groups		1	48
Niagara Frontier	339	9	
Group: Technical		3	12
Niagara International	156	17	17
North Carolina	353	2	
Subsections: Charlotte		8	
Eastern North Carolina		6	16
Northeastern Michigan	136	12	12
Northern New Mexico	209	13	13
North Texas	611	10	
Groups: Aircraft Electric		2	
Electronics		2	
Industrial		1	
Transmission and Distribution		3	
Subsections: Central Texas		8	
Fort Worth		5	
West Central Texas		8	
Joint Meetings: Section and Fort Worth Subsection		1	40
Oak Ridge	116	11	11
Ohio Valley	92	14	14
Oklahoma City	227	9	
Groups: Communications		4	
Electronics		5	
Industrial Practices		7	
Power Systems		7	32
Ottawa	86	9	9
Panhandle Plains	170	9	
Group: Technical		5	14
Philadelphia	1,927	14	
Groups: Aircraft Electric Systems		4	
Basic Sciences		3	
Communications		4	
Computer		4	
Electronics		3	
Industrial Practice		3	
Instruments and Measurements		3	
Power Systems		3	
Subsection: Atlantic City		2	
Joint Meetings: Section and Computer Group		1	44
Pittsburgh	1,358	3	
Groups: Communications		1	
General Meetings		1	
Industry		2	
Power Generation		3	
Science and Electronics		2	
Transmission and Distribution		2	
Subsections: Centre County		5	
Johnstown		9	
Joint Meetings: Section and Industry Group		2	
Section and Communications Group		1	
Section and Transmission and Distribution Group		1	32
Pittsfield	347	13	13
Portland	608	18	18
Providence	174	8	8
Richland	147	11	11
Ridgway	61	9	9

Table I (continued). Section Membership, August 1953; Section Meetings During Year Ending April 30, 1953

Section	AIEE Members August 1953	Number of Meetings	Total Number of Meetings
Rochester	248	17	
Group: Technical		3	20
Rock River Valley	112	9	9
Sacramento	126	12	12
St. Louis	778	9	
Groups: Basic Sciences		6	
Electronics		1	
Industrial Apparatus		8	
Industrial Power Practices		9	33
San Diego	203	12	
Group: Technical		1	13
San Francisco	1,559	25	
Group: Industrial		2	
Subsections: Fresno		8	
Hawaii		10	
San Jose		9	
Shasta		8	62
Schenectady	1,163	19	
Subsection: Adirondack		6	25
Seattle	706	12	
Groups: Aircraft		7	
Basic Science		2	
Power		6	
Transportation		6	
Subsection: Tacoma		9	
Joint Meetings: Aircraft and Power Groups		1	
Section and Tacoma Subsection		1	44
Sharon	243	14	
Subsection: Youngstown		4	18
Shreveport	141	11	
Subsection: Monroe		1	12
South Bend	143	12	12
South Carolina	207	0	
Subsection: Columbia		13	13
South Texas	145	10	10
Spokane	175	14	14
Springfield	126	9	
Group: Technical		4	13
Syracuse	379	8	
Subsections: St. Lawrence International		5	
St. Lawrence International Discussion Group		1	14
Tampa	144	4	4
Toledo	180	12	
Groups: Motors and Controls		2	
Power Systems		3	17
Toronto	691	11	
Groups: Communications		3	
Discussion		10	
Subsection: Hamilton		8	
Joint Meetings: Section and Hamilton Subsection and Communications Group		1	
Section and Discussion Group		1	
Section and Communications Group		1	
Section and Hamilton Subsection		1	36
Tulsa	227	9	
Group: Technical Session		17	26
Utah	171	10	10
Vancouver	289	10	
Group: Discussion		8	
Subsection: Vancouver Island		9	27
Virginia	237	2	
Subsections: Hampton Roads		7	
Richmond		4	13
Virginia Mountain	109	5	5
Washington	1,125	7	
Groups: Basic Science		2	
Communications—Instrumentation—Electronics		2	
Nucleonics		1	
Power		2	14
West Virginia	117	12	12
Wichita	138	13	13
Worcester	118	8	8
	42,908		1,793

Total Sections, 97
Total technical groups, 123
Total Subsections, 51

Table II. Branch Meetings Held During Year Ending April 30, 1953

Branch	Number of Meetings
*Akron, University of	7
Alabama Polytechnic Institute	10
Alabama, University of	10
*Alberta, University of	7
*Arizona, University of	
*Arkansas, University of	28
*British Columbia, University of	24
Brooklyn, Polytechnic Institute of	
Day Division	6
Evening Division	7
*Brown University	5
*Bucknell University	4
*California Institute of Technology	3
*California, University of	34
*Carnegie Institute of Technology	58
Case Institute of Technology	8
Catholic University of America	7
Cincinnati, University of	10
Clarkson College of Technology	7
Clemson A & M College	2
Colorado A & M College	15
*Colorado, University of	13
*Columbia University	1
*Connecticut, University of	11
*Cooper Union	8
*Cornell University	8
*Delaware, University of	6
*Denver, University of	8
*Detroit, University of	4
*Drexel Institute of Technology	6
Duke University	9
Fenn College	7
*Florida, University of	7
George Washington University	7
Georgia Institute of Technology	
Howard University	7
Idaho, University of	14
Illinois Institute of Technology	14
*Illinois, University of	5
Chicago Division	22
*Iowa State College	8
Iowa, University of	12
*Johns Hopkins University	19
Kansas State College	13
*Kansas, University of	8
Kentucky, University of	7
*Lafayette College	8
Lehigh University	6
Louisiana Polytechnic Institute	12
*Louisiana State University	13
Louisville, University of	9
*Maine, University of	7
*Manhattan College	4
*Marquette University	3
*Maryland, University of	7
*Massachusetts Institute of Technology	7
*Massachusetts, University of	7
*Michigan College of Mining and Technology	16
*Michigan State College	7
*Michigan, University of	1
Milwaukee School of Engineering	9
*Minnesota, University of	6
Mississippi State College	9
*Missouri School of Mines and Metallurgy	12
*Missouri, University of	8
*Montana State College	7
*Nebraska, University of	12
Nevada, University of	11
Newark College of Engineering	7
*New Hampshire, University of	3
*New Mexico College of A & M Arts	9
*New Mexico, University of	5
*New York, College of the City of	11
*New York University	
Day Division	25
Evening Division	4
*North Carolina State College	9
*North Dakota State College	9
*North Dakota, University of	4
*Northeastern University	30
*Northwestern University	17
Norwich University	2
*Notre Dame, University of	10
Ohio Northern University	9
*Ohio State University	14
*Ohio University	5
*Oklahoma A & M College	9
Oklahoma, University of	8
*Oregon State College	11
*Pennsylvania State College	10
*Pennsylvania, University of	13
Pittsburgh, University of	17
*Pratt Institute	9
*Princeton University	3
Puerto Rico, University of	2
Purdue University	7
*Rensselaer Polytechnic Institute	5
*Rhode Island, University of	3
Rice Institute	4
Rose Polytechnic Institute	6
*Rutgers University	9
Saint Louis University	1
Santa Clara, University of	8
*South Carolina, University of	6
South Dakota School of Mines and Technology	4
South Dakota State College	7
*Southern California, University of	12
*Southern Methodist University	6
*Stanford University	5
*Stevens Institute of Technology	6
Swarthmore College	3
*Syracuse University	
Tennessee, University of	4
*Texas A & M College	5
*Texas Technological College	12
*Texas, University of	1
Texas Western College Sub-Branch	6
*Toledo, University of	4
Toronto, University of	18
*Tufts College	8
*Tulane University	5
Union College	10
United States Naval Academy	1
*Utah, University of	17
Vanderbilt University	10
Vermont, University of	1
*Villanova College	16
Virginia Military Institute	6
*Virginia Polytechnic Institute	28
*Virginia, University of	4
Washington, State College of	13
*Washington, University of	19
Washington University	6
*Wayne University	8
*West Virginia University	8
*Wisconsin, University of	9
*Worcester Polytechnic Institute	
*Wyoming, University of	4
*Yale University	7
	1,234

Total Branches, 133

* Joint AIEE-IRE Branches (85)

OF CURRENT INTEREST

Engineering Development and Research Improves Motor Design and Performance

Better protection, more efficiency, and quieter operation are brought out in a new ine of polyphase a-c motors announced by the General Electric Company's Small Integral and Medium Induction Motor Departments. Called Tri-Clad* *55*, the new motors are the result of more than 250,000 man-hours of developmental engineering and research. Built to latest standard National Electrical Manufacturers Association frame dimensions, they feature entirely new and advanced concepts of motor design.

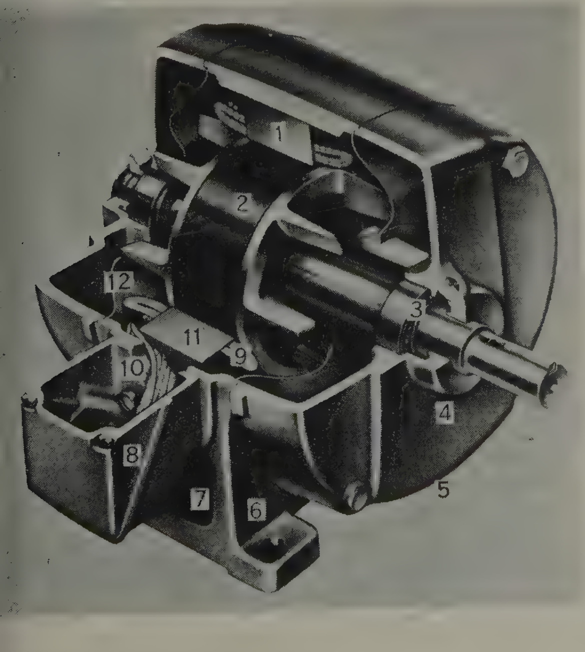
With an average size reduction of 50 per cent by volume and averaging 22 per cent less weight per horsepower, the *55* retains rigid cast-iron construction and incorporates a new insulation system, bearing assembly, and ventilation plan.

The keystone of the insulation system is a new polyester film which is eight times as strong as previously used materials and combines tensile strength with high dielectric qualities. It is used to insulate the phases and slot tubes in the stator, the points of hardest motor wear. This synthetic material, combined with Formex* wire, an improved Glyptal* varnish, and a silicon Dri-film* dip, has withstood accelerated life tests and salt-spray tests better than any other system tried. The Formex wire helps protect the motor against full-voltage starting stress, heat aging, and heat shock. Dri-film, into which the rotor is dipped after receiving a coat of Glyptal varnish, makes the windings water repellent. Nonwicking leads, insulated with nonhydroscopic material, minimize the harmful effects of water and are stamped permanently with numbers to facilitate maintenance throughout the motor's life.

The new bearing assembly is more tightly sealed and is lubricated by a grease which lasts at least five times longer than formerly used lubricants. Extensive tests were conducted to develop a new bearing system that would give the longest possible life without relubrication. The new bearing housing was designed to hold just the right amount of new synthesized greases. Heavy-duty ball bearing plus an effectively sealed cast-iron bearing housing complete the system.

A double-end ventilation system uniformly cools the motor by drawing air in from beneath both end shields, through carefully baffled air passages, and out louvers on the sides of the frame. Larger integrally cast rotor fans increase the cooling air flow through the motor and dissipate rotor heat more effectively. Protection has been increased by 60 per cent on the drip-proof enclosure through new end-shield and frame design.

A major part of the new motor design involves noise levels. Tests conducted in a specially constructed sound laboratory revealed that there were three main causes of irritating motor noise: magnetic hum, bearing rattle, and windage, the rush of air through the motor. Spring loading bearings and maintaining closer tolerances between the outer race and the bearing housing reduce the bearing rattle. Magnetic hum has been controlled through design of the rotor and stator punchings. Careful acoustical design of the air passages and the ventilation air baffle reduced windage noise. The result is a quieter motor and one which sounds more pleasing to the human ear. Each Tri-Clad *55* must pass a quality control sound test before leaving the factory. The noise level of the new 10-horsepower motor tests as low as the former 2-horsepower model.



Outstanding features of General Electric's drip-proof motor design; (1) polyester film slot and phase insulation; (2) solid-cast rotor windings; (3) sealed bearing system; (4) end shields; (5) shaft-end air intake of double-end ventilation system; (6) rigid cast-iron construction; (7) ventilation exhaust; (8) conduit box; (9) stator windings; (10) permanently numbered leads; (11) press-fitted stator punchings; (12) sonance designed ventilation baffle

The totally enclosed fan-cooled motor also has been redesigned. Electrical parts are enclosed completely by tightly sealed cast-iron frame and end shields, a compression-fit lead seal, and a rotating labyrinth seal on the shaft. A new "jet" ventilation system blankets the frame with cooling air. Plastic fan, stainless steel name plate, and other exposed parts are corrosion-resistant.

Besides the longer life lubricating grease, other improved maintenance features include a larger diagonally split conduit box, knock-off lugs on the end shields, and location of the combination name-plate–connection diagram directly over the box.

Frame and end shields are made of rigid cast-iron in the new Tri-Clad. The aluminum rotor is cast by a special pressure-vacuum process, resulting in greater conductivity and physical strength. Rotor punchings are given a special treatment to reduce core loss and stray load loss. The motor has a prewound stator core with the laminations

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*Registered Trade-Marks of the General Electric Company.

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers and The American Society of Mechanical Engineers. Joint Fuels Conference. October 29–30, 1953, The Conrad Hilton, Chicago, Ill.

Exposition of Chemical Industries. 24th Exposition. November 30–December 5, 1953, Commercial Museum and Convention Hall, Philadelphia, Pa.

Industrial Management Society. 17th Annual Time and Motion Study and Management Clinic. November 4–6, 1953, Sheraton Hotel, Chicago, Ill.

Institute of Radio Engineers, Kansas City Section. Annual Electronics Conference. November 13–14, 1953, Hotel President, Kansas City, Mo. Institute of Radio Engineers, Vehicular Communications Group. 4th Annual Meeting. November 12–13, 1953, Hotel Somerset, Boston, Mass.

Institute of the Aeronautical Sciences. 17th Wright Brothers Lecture. December 17, 1953, United States Chamber of Commerce Building, Washington, D. C.

National Association of Corrosion Engineers. Western Region. November 16–20, 1953, University of California at Los Angeles, Los Angeles, Calif.

National Electrical Manufacturers Association. November 9–12, 1953, Haddon Hall Hotel, Atlantic City, N. J.

Refrigeration and Air Conditioning Exposition. 8th All-Industry Show. November 9–12, 1953, Public Auditorium, Cleveland, Ohio

Society of Automotive Engineers. International Production Meeting. October 29–30, 1953, Royal York Hotel, Toronto, Ontario, Canada

Society of Automotive Engineers. National Diesel Engine Meeting. November 3–4, 1953, The Conrad Hilton, Chicago, Ill.

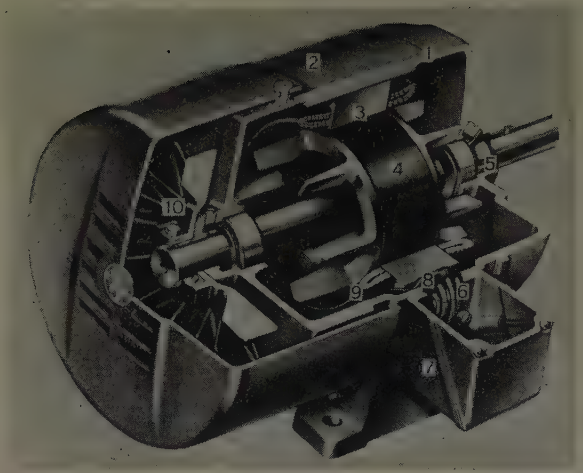
Society of Automotive Engineers. National Fuels and Lubricants Meeting. November 4–6, 1953, The Conrad Hilton, Chicago, Ill.

Society of Automotive Engineers. National Transportation Meeting. November 2–4, 1953, The Conrad Hilton, Chicago, Ill.

Southeastern Electric Exchange. General Sales Conference. November 19–20, 1953, Biltmore Hotel, Atlanta, Ga.

The American Society of Mechanical Engineers. Annual Meeting. November 29–December 4, 1953, Statler Hotel, New York, N. Y.

The American Society of Mechanical Engineers, Instruments and Regulators Division. Symposium on Frequency Response. December 1–2, 1953, New York, N. Y.



Outstanding features of General Electric's totally enclosed fan-cooled motor; (1) moisture-proof sealing compound; (2) cast-iron enclosure; (3) polyester film slot and phase insulation; (4) solid cast rotor windings; (5) labyrinth seal; (6) permanently numbered leads; (7) conduit box; (8) compression-tight seal; (9) water-shedding stator windings; (10) split-hub Textolite fan

inert-arc-welded, providing a lightweight assembly and better standardization of parts. Every rotor is dynamically balanced.

Although size and weight have been materially reduced and new design concepts incorporated, the Tri-Clad *55* has a higher full-load speed rating and greater efficiency than the former motor.

Two completely new manufacturing facilities utilizing some unique manufacturing techniques have been established to make the new line of motors. A new factory in Fort Wayne, Ind., will manufacture the 1- to 5-horsepower motors and a new factory in Schenectady, N. Y., will handle the $7^1/_2$- to 30-horsepower range.

After January 1954, the new motors will be available in 1, $1^1/_2$, and 2 horsepower at 1,800 rpm in horizontal drip-proof and totally enclosed fan-cooled models, and a complete line of gear-motors. Larger frame sizes will become available at regular intervals. Other types planned for production during 1954 include vertical, single-phase, wound-rotor, explosion-proof, multispeed, face-mounted, and flange-mounted models.

Automatic Production Line Developed for Electronic Products Manufacture

An automatic production line for the manufacture of electronic products and a novel system of electronics design which makes this possible have been developed by the National Bureau of Standards (NBS). The program, code-named Project Tinkertoy, was sponsored by the Navy Bureau of Aeronautics.

Starting from raw or semiprocessed materials, machines automatically manufacture ceramic materials and adhesive carbon resistors, print conducting circuits, and mount resistors, capacitors, and other miniaturized component parts on standard uniform steatite wafers. The wafers are stacked very much like building blocks to form a module that performs all of the functions of one or more electronic stages. Automatic inspection machines check physical and electrical characteristics of the parts-mounted wafers at numerous stations along the production line. The completed module is a standardized, interchangeable subassembly combining all of the requirements of an electronic circuit with ruggedness, reliability, and extreme compactness.

Project Tinkertoy was begun by NBS in May 1950 and now successfully produces electronic subassemblies by mechanized means. The pilot plant is operated by a commercial contractor as part of a large-scale production evaluation program under the Bureau's technical direction. The basic objective of the Navy Bureau of Aeronautics in establishing the program was the development of facilities or systems suitable for rapid mobilization in emergency periods. The facilities are also dual-purposed in nature and are expected to reduce lead time substantially in production.

The key to the automatic, mechanized production of electronic equipment in Project Tinkertoy is the design system developed by NBS. Called MDE—for Modular Design of Electronics—the system establishes a series of mechanically standardized and uniform modules, producible with a wide range of electrical characteristics.

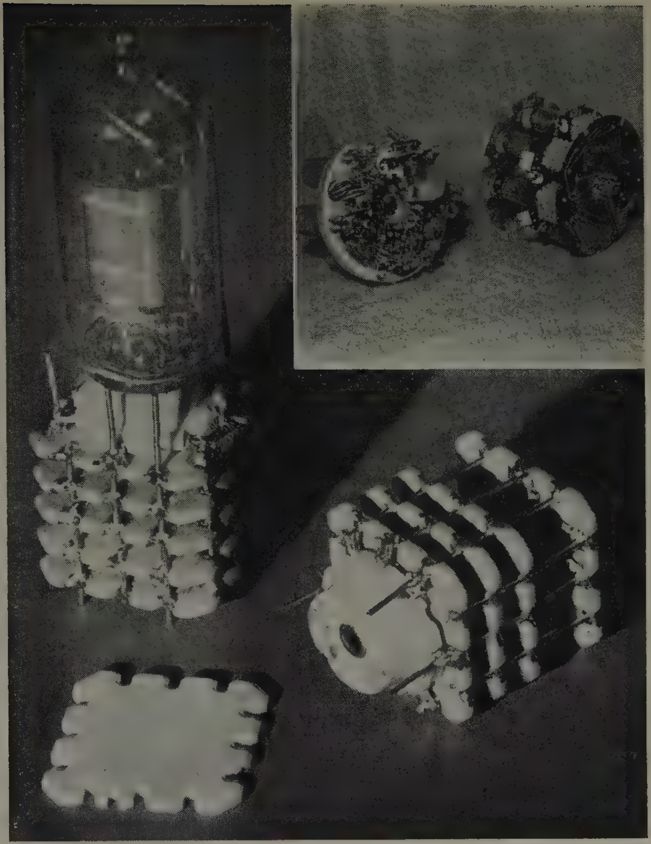
Each module, in general, consists of some four to six thin ceramic wafers, bearing various circuits associated with an electronic stage. A number of individual modules are combined to form a major subassembly. The composition of modules into major subassemblies of electronic equipment is possible because there is great similarity between circuits and parts of circuits in modern electronic equipment.

Electronic assemblies consist largely of electronic tubes and arrays of simple parts like resistors and capacitors which account for the mass of the individual parts and also are responsible for the bulk of the manual production efforts in conventional production. These assemblies have been the chief target for redesign in the MDE system.

The production of modules and assemblies, designed in accordance with the MDE system, is achieved mechanically in Project Tinkertoy. The production system developed by NBS is called MPE—Mechanized Production of Electronics. MPE largely utilizes noncritical raw materials. Ceramic wafers, $^7/_8$ inch square by $^1/_{16}$ inch thick, are produced directly in quantity from the raw ingredients. Ceramic capacitors are produced in a similar fashion. Another part of the line produces adhesive tape resistors.

These and other basic parts are fed into the production line. The appropriate circuits are printed by automatic machines. The circuit configuration is achieved through photographic processing. Quality control is established by automatic inspection, directed by information prepared in punched card form. Special components, not suitable for

(Left) Interior of Project Tinkertoy pilot plant. (Right) Robert Henry, NBS project leader and the MPE inspector. After the wafers have been assembled, the electronic system inspects each circuit or component part



(Right) Two modules and a wafer illustrating the modular design of electronics. (Insert) Electronic equipment produced by conventional component parts and (right) MPE version of the same piece of equipment

"printing" techniques, can be incorporated into the modules. Automatic physical and electrical inspection is provided for in the production line.

The MPE system is based on the use of bulk or semiprocessed materials, and the line produces all the large-quantity parts except for the tubes. The pilot plant is designed for a production goal of 1,000 modules per hour. Joining modules together to form subassemblies also may be accomplished by machines.

MDE is the basis for the Project Tinkertoy system. In such a system flexibility of product and the general characteristics of conventional assembly methods are compatibly combined. At the same time product standardization and uniformity—the prerequisites for economical processing by automatic machinery—are integral aspects of the system. Interconnection is relatively simple between any number of modular units. By combining modular assemblies containing different component parts, whole electronic circuits may be developed to amplify signals, generate and shape waveforms, scale count, and perform customary electronic functions.

The MDE design system dispenses with the conventional circuit diagram of the tested electronic model and places all necessary production programming information on an MDE work sheet. Each work sheet contains the front and back outlines of six wafers with appropriate numbering to identify each notch in the wafer, each riser wire, and the electronic piece that is to be placed on the wafer. The engineer translates his conventional wiring diagram to an MDE diagram. He indicates the position of the piece and its proper value and tolerances. Lines are drawn to indicate how the circuits between wafers are to be connected.

The engineer's MDE work sheet becomes the basic document from which a draftsman draws an ink drawing that may be reproduced in large numbers. The draftsman also prepares a larger version of the work sheet that is photographed and is subsequently used to make stencils for the circuit printing machines. The numbers of wafers and the tube sockets listed on the MDE work sheets give an indication of the quantity of raw ceramic materials that must be mixed. The number and value of resistors marked on the work sheets determine the production required for tape resistors.

The MDE work sheet also is used to establish the inspection procedure. Current paths on each wafer are marked on specially prepared punch cards. These cards accompany the wafers through all of the manufacturing processes. The sheet is also used in the construction of the standard modules or counterparts that are employed in the final testing and inspection of the module assembly.

Engineering Manpower Commission Announces Program for 1954

The Engineering Manpower Commission (EMC) of Engineers Joint Council (EJC) has announced its program for 1954. This program has been approved by EJC.

EMC was organized in the fall of 1950 to work on the problems created by the critical shortage of engineers. Its threefold broad objectives are to aid in establishing the importance of engineering to the national economy, to aid in maintaining the supply of trained engineers, and to promote the most effective utilization of engineers in the national health, safety, and interest.

At the present time, the nation is faced with a high demand for engineers and the results of a decreasing number of engineering graduates. The reasons for the high demand for engineers can be found in (1) the high rate of industrial growth and expansion; (2) an increasing use by both industry and government of scientific and engineering advances resulting in an increase in the proportion of engineers to gainful workers; (3) a demand by the military for its operating needs. Because of decreasing graduating classes, caused by a number of factors, the number of engineering graduates over the past several years has been considerably less than those needed in the total economy. There is reason to believe that the demand for engineers will remain high for years to come.

The broad objects of the EMC program for 1954 will be (1) to co-operate with industry, with government, and with private agencies to secure better utilization of engineers; (2) to co-operate with responsible Federal, State, educational, and industrial agencies concerned with engineering manpower in developing (*a*) accurate statistics and forecasts of supply and demand, (*b*) determination of the distribution of the supply of new engineering graduates, (*c*) improvement in quality and quantity of new engineering graduates through better qualification and interest in high school students; (3) to maintain a continuing surveillance of the national scene with respect to engineering manpower so as to provide a clearing house of information for, and a channel of communication between, the profession, industry, government, and others on this subject; (4) to secure even closer co-ordination of engineering and scientific manpower activities; (5) to secure and maintain an adequate flow of students into the engineering colleges through the promotion of interest in and knowledge of the work of the engineering profession.

In carrying out these broad objectives, EMC will maintain close contact with industry, with the engineering colleges, and with such agencies as the Office of Defense Mobilization (ODM), the United States Office of Education, the National Research Council, the ODM Committee on Specialized Personnel, the National Planning Association, the Armed Services Committees of the Congress, the American Council on Education, the National Science Teachers Association, the Thomas Alva Edison Foundation, the National Manpower Council of Columbia University, the Scientific Manpower Commission (SMC), the committees concerned with manpower of such organizations as the National Association of Manufacturers, the American Chemical Society, the Chamber of Commerce of the United States, the National Electrical Manufacturers Association, and others, and other activities concerned with manpower policies and problems affecting engineers.

With respect to SMC, EMC will coordinate its activities with those of SMC to the end that the interests of the engineering and scientific professions, industry, and other clientele of these professions will be served fully with a minimum of duplication of effort. As examples, it is planned that: (1) the Engineering Manpower Newsletter will become a joint publication of both EMC and SMC; (2) a conference of scientific and engineering manpower resources will be conducted under the joint sponsorship of EMC and SMC.

In forwarding the broad objectives of its 1954 program, EMC will, more specifically: (1) Strive for better distribution of engineers between the military, educational, and industrial parts of our economy. (2) Promote the use of technical institute graduates and those who only partially complete engineering courses in the colleges in supplementing the work of graduate engineers. (3) Continue to recommend amendment of the Armed Forces Reserve Act of 1952 (P. L. 476) to provide for a properly balanced allocation between the military and other essential activities of those persons having special proficiencies and experience. Such persons should be distributed to meet the needs of military mobilization and at the same time preserve nonmilitary activities required to support mobilization and otherwise necessary in the national health, safety, and interest. (4) Continue its annual studies of demand for engineers in industry and governmental activities and in education. (5) Continue its surveys in the engineering colleges to determine the probable distribution of the supply of engineers. (6) Continue its program to encourage and facilitate the return to engineering occupations in industry of those engineering graduates who, in increasing numbers, are leaving military service after varying periods of active duty. (7) Continue its program to interest qualified high school students in careers in engineering. In this area, EMC will (*a*) support the local activities of the Engineers' Council for Professional Development; (*b*) work toward securing adequate high school curricula in science and mathematics; (*c*) encourage such organizations as the Future Scientists of America Foundation sponsored by the National Science Teachers Association. Assistance will be given to such organizations as the Future Scientists of America but it is contemplated that this assistance will be of an informational and advisory nature rather than financial. (8) Provide assistance to various activities requiring information on the engineering manpower situation. This will include information and aid to individuals, to industry, and to organizations in connection with deferment policies of selective service, recall policies and procedures of the Department of Defense, as well as aid in obtaining outstanding and well-qualified persons as speakers on the subject of engineering manpower. (9) Continue to disseminate the results of its activities and research to industry, government, and other interested individuals and activities through the medium of newsletters, special reports, and other means.

Public relations activities of EMC will be continued to supplement all of these steps. The over-all public relations program will continue to emphasize the importance of engineers and engineering to the national economy and to the defense mobilization effort.

New Method of Depositing Phosphors Simplifies Color Tube Construction

The CBS-Colortron is an aluminized, direct-view, tricolor picture tube designed for use in color-television receivers. Electromagnetically deflected and electrostatically focused, the CBS-Colortron has a deflection angle of 45 degrees, and an over-all length of 26$^1/_8$ inches. It provides a choice of full-color or black-and-white pictures on a screen area of approximately 104 square inches.

This tube employs an all-glass construction and incorporates a unique mask-and-screen assembly, the simplicity of which facilitates the use of low-cost mass-production techniques.

The electron-gun assembly contains three matched, electrostatic-focus electron guns, each similar to the gun used in the *5TP4* projection-type black-and-white tube, also manufactured by CBS-Hytron. The three guns are arranged in a triangular configuration, with each gun aligned parallel to and equidistant from the tube axis. The guns also are displaced from each other by an angle of 120 degrees, measured in a plane perpendicular to the tube axis.

By a unique method of screen processing, the tricolor phosphor-dot screen is placed directly on the inside surface of the spherical face plate of the tube. In addition to achieving simple construction and high-quality reproduction, many electrical and structural advantages are realized, because of this advanced design. Dynamic focusing and convergence requirements are reduced to a minimum; sharper, brighter pictures result; adjustment time is reduced to a minimum; and a simple, stable over-all tube construction is attained.

The phosphor screen of the CBS-Colortron contains some 250,000 phosphor dots of each primary color, a total of 750,000 phosphor dots. These dots are arranged in 250,000 triangular groups, or triads. Each triad contains one red, one blue, and one green phosphor dot.

Another component of the tube is the aperture mask. This thin, arched mask is located between the phosphor screen and the electron-gun assembly. It contains approximately 250,000 round holes, one for each triad on the screen. Since the position of these holes relative to the triads is of paramount importance for proper tube operation, the mask is accurately positioned with relation to the triads and is approximately 0.4 inch behind the phosphor screen.

As can be seen in Figure 1, the mask assembly consists of the curved mask with spring clips to hold it in place. This assembly is mounted on three hemispheres, which are raised points of glass molded around the edge of the face plate, beyond the picture area.

The mask contains three V-shaped surfaces which rest over the hemispheres and make use of the kinematic principle of precise location. Since the mask is unstressed, it is free to expand and contract. This combination of a curved face plate and a curved, unstressed mask automatically permits expansion and contraction without misregistration.

Recognizing the advantages to be obtained from this combination of a curved face plate supporting the phosphor dots and a curved mask, a method has been developed for depositing the phosphors on a curved surface which is simple and accurate, as well as one that appears to be suited to mass-production processes. This method employs a photographic technique which is similar to photoengraving in many respects. By using this technique, settling of the three phosphors is done in the same manner currently used for black-and-white picture tubes. One of the three colored phosphors is laid down first and is allowed to cover the entire screen. After drying, a photosensitive material is coated over the phosphor. This is then exposed to light through the aperture mask which serves as a negative.

When exposing the screen, a pin-point light source is accurately positioned so as to be in the exact location that the beam from the associated electron gun will occupy when the face plate is assembled into the finished tube. Light passes through the holes in the aperture mask and exposes the photosensitive material in a pattern of dots all over the screen. The exposed areas, upon consequent development will bind the phosphor beneath them to the face plate; however, all of the remaining phosphor lying beneath the unexposed photosensitive layer will be washed away. This leaves one complete dot array containing the phosphor material necessary to produce one of the three primary colors.

By depositing over the entire screen again a second colored phosphor and by using the same aperture mask, but with the light source moved so as to coincide with the future posi-

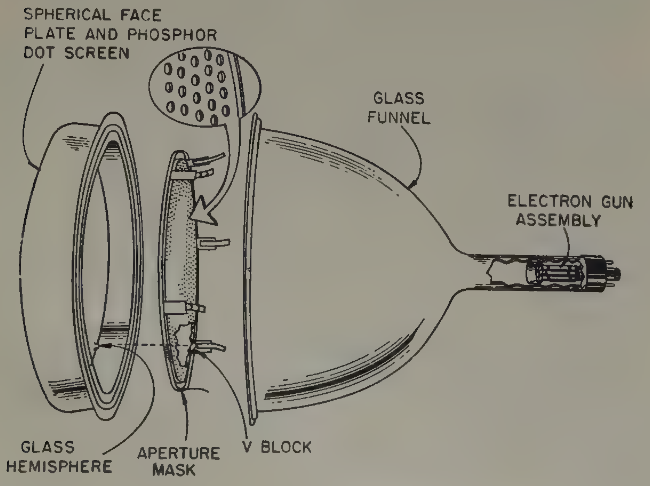


Figure 1. Exploded view of the CBS-Colortron showing its internal components

tion of the electron beam from the second gun, the former process is repeated. The second array of dots is appropriately spaced between the dots of the first array. Repeating the process for the third phosphor completes the printing of the screen. Note that this technique may be used to apply the phosphors in proper registry directly onto the face plate, regardless of its shape or curvature.

Radar Speed Measurer Helps Carrier Planes Land More Safely

The lives of Navy jet pilots and the complex and costly aircraft they fly are being safeguarded by a remarkable new electronics device that "clocks" an approaching plane and indicates whether or not it is coming in at a safe landing speed.

The new radar speed-measuring equipment developed by Raytheon Manufacturing Company of Waltham, Mass., was made under the joint auspices of the Navy's Bureaus of Aeronautics and Ships, to help fast-flying jets land safely on aircraft carriers.

Military secrecy was lifted as naval authorities described the new device. Installed on the carrier, it "watches" the approach of a plane coming down for a landing, and warns the landing signal officer if the plane's speed is too fast or too slow. The officer then wig-wags his orders to the pilot, either guiding him down to a landing, or waving him off for another try.

Too fast a speed, of course, would cause a jet to "overshoot" the arresting cables or the entire deck. Too slow a speed is extremely dangerous, for the airplane becomes wobbly, and may stall in mid-air, plummeting into the sea or onto the deck with destructive force. With jet aircraft, unlike propeller-driven planes, there is only a narrow spread between too fast a speed and too slow. Pilots find it increasingly difficult to control the speed of modern fighter craft within the limits allowed by carrier operations.

The new speed-measuring equipment takes into account automatically the speeds of the aircraft and the carrier, and coordinates this information with the wind's speed to give an accurate and reliable reading of the true airspeed of the plane. The landing signal officer uses this information to help him bring the airplane safely aboard the carrier.

Several of the Navy's aircraft carriers that have had the new Raytheon speed measurement device installed, have reported a gratifying increase in safety through reduced accidents during landing operations. Even without the improved safety for human lives, it was claimed, the dollars-and-cents savings justify the use of the new device. Today's jet fighters cost from $200,000 to half a million dollars apiece, and even a nonfatal accident can cause enormously expensive damages to the plane and the ship.

The speed-measuring equipment was described by Raytheon engineers as the first triumph in a project to develop a complete, carrier-controlled system for guiding the approach and landing of aircraft. Someday it may be possible for the landing signal officer to take over and actually fly the airplane on its final approach to the deck—even though he is not in the air himself. He would do it by watching the plane's approach via the speed indicator, and operating a set of controls on the deck that are connected electronically to the plane's automatic pilot.

Meantime, the speed-measurement device alone is expected to have a tremendous impact on all-weather flying.

Landing Signal Officer uses conventional wig-wag flags to guide jet pilot safely down to carrier deck, but is aided by the low-mounted dial of new speed indicator (in lower left-hand corner)

Tantalum Capacitor Will Enable Size Reductions in Assemblies

A tiny tantalum capacitor, believed to be the smallest high-capacity unit ever designed for low-voltage d-c applications, has been announced by the General Electric Company.

It will make possible further size reductions in miniaturized assemblies using transistors and is intended as a companion for the transistor.

The new unit is so small—5/16 inch long and 1/8 inch diameter—that it has been termed a "micro-miniature" capacitor. It is the first in a new line of small capacitors being developed by General Electric for miniaturized equipment.

The capacitor can be used in hearing aids and, in many instances, can be applied in transistorized military equipment. It will aid also in opening the door for commercial applications of miniature electronic products.

The major feature of the unit is the advantage in size per volt microfarad over most other electrolytics. Other features include: long shelf and operating life, wide temperature range, and low leakage current. The unit is sealed against leakage or contamination and utilizes a nonacid electrolyte.

It is designed to operate over a temperature range of −20 degrees centigrade to +50 degrees centigrade and is suitable for storage at −65 degrees centigrade.

The new unit is available in ratings from 2 to 16 volts, 4 to 0.7 microfarad respectively. Another, larger capacitor—1/2 inch long—with similar characteristics and the same voltage range, but with 8 to 1.5 microfarads, also has been announced as available.

While temperatures below −20 degrees centigrade will result in further loss of capacitance, the new units continue to be operable and often will give satisfactory values at much lower temperatures. At 10 volts or above and at −55 degrees centigrade, the capacitors will maintain at least 65 per cent of its 25-degree-centigrade value, according to advance tests. It is also possible to obtain satisfactory performance above 50 degrees centigrade with some life restrictions.

The units are recommended for nonresonant, noncritical applications such as coupling, by-pass, and filtering.

The capacitors have a tantalum anode oxidized to the voltage rating, enclosed in a silver case, and impregnated with nonacid solution. A synthetic plug in the end of the case is roll-crimped into place and a solderable tin-coated nickel lead is lap-welded externally to the projecting tantalum anode lead, permitting connection up to the case. The case itself is the cathode, and is equipped with a tin-coated copper lead soldered to the case. The units are of the polarized type.

Robot Scanner Monitors Naval Bearing Temperature

An automatic electronic temperature-monitoring system designed to eliminate engine shutdowns due to bearing "burnouts" has been developed for the United States Navy, it was announced recently by the Minneapolis-Honeywell Regulator Company.

A number of the new systems are being produced under a contract with the Bureau of Ships. Neither the number of systems nor the amount of the contract was disclosed.

Heart of the automatic system is an electronic scanning instrument capable of checking temperatures in 40 critical locations (usually in the turbine areas) in 10 seconds. If the scanner detects an unsafe temperature at any point, an alarm sounds and a light glows on the instrument face pin-pointing the trouble spot. Under present procedures a seaman either makes scheduled in-person checks of bearing thermometers—a time-consuming job and subject to the possibility of human error—or interprets data on recording instruments to determine temperature conditions.

According to the Honeywell engineers,

overheated turbine bearings can disable a ship. The situation is aggravated further by the fact that such burnouts may occur under combat conditions primarily because of the unusual strain put on the ship's engines during such times. They saw the trend toward increased operating power in today's naval vessels contributing to the need for precise measurement of bearing temperatures.

Describing the operation of the new system, the engineers explain that 40 thermocouples are imbedded in as many bearings. These thermocouples are linked to the scanner. Operating on a continuing basis the scanner automatically reviews temperatures in all 40 points every 10 seconds—or six complete checks of all critical points every minute. When a "hot" bearing is detected, the alarm sounds and a light glows to alert the attending seaman. He, in turn, operates a selector switch to determine the exact temperature of the bearing in question. Corrections then can be made before a dangerous situation is reached.

Over-all view of the Hydro-Quebec, world's largest hydraulic pipe-line dredge which contains an estimated $500,000 of electric apparatus

World's Largest Dredge Powered by $500,000 of Electric Apparatus

The world's largest hydraulic pipe-line dredge, capable of digging and disposing of boulders weighing as much as 1,500 pounds, is powered and controlled by General Electric equipment.

An estimated $500,000 of electric apparatus, including motors, motor-generator sets, high-voltage switchgear, transformers, and control is used on the *Hydro-Quebec*, a 280-foot vessel that displaces 2,500 long tons. The dredge is being used to clear the entire 3,300-foot width of the 15-mile-long Beauharnois Canal between Lake St. Frances and Lake St. Louis in Quebec, Canada, to a depth of 35 feet.

The operation, expected to move more than 50 million tons of tough boulder clay, is designed to provide more water for the Quebec Hydro-Electric Commission's expansion of the Beauharnois powerhouse. When the work is completed, the station will be the largest single-site hydroelectric plant in the world with an output of more than 2,000,000 horsepower.

An 8,000-horsepower 257-rpm wound-rotor induction motor, largest ever used on dredge, drives the *Hydro-Quebec's* single-suction centrifugal pump, capable of sucking up and discharging 28-inch glacial boulders. The giant 18-foot-diameter motor receives a 13.8-kv 3-phase 60-cycle power supply directly from the utility via a 4,000-foot submarine cable laid on the bottom of the canal with excess cable wound on a water-sprayed reel on a scow adjacent to the dredge. A 36-inch pipe line supported by pontoons, carries the pump discharge more than 3,000 feet to settling basins on the shore.

An 85-foot ladder carrying a 26-ton cutter head with renewable teeth mounted on spiral blades permits the dredge to dig a maximum depth of 50 feet. The cutter, which can operate at a 45-degree axial tilt, uses a 1,000-horsepower totally enclosed d-c motor to drive the cutter head which digs the heavy boulders and sticky marine clay without prior preparation by blasting. The specially built cutter motor has forced ventilation provided by a $7^1/_2$-horsepower integrally mounted blower motor and is of extra rugged construction to withstand the extreme vibration present while operating at a steep tilt. A 10-kw 250-volt amplidyne regulating system controls speed and load regulation of the cutter motor.

In addition to motors, General Electric supplied a 3-kw 125-volt amplidyne control system for the pump motor whereby load may be regulated at a constant value selected by the operator in the pilot house. An independent auxiliary manual control permits selection of the secondary resistance of the 8,000-horsepower motor from the pilot house. Interlocked features in the pump control provide maximum protection of the electric equipment from damage due to overloads, or human, electrical, or mechanical failures.

Three 600-kva transformers step current down from 13,800 volts to 2,400 volts to feed the motor-generator sets for the cutter head and the hauling and hoisting machinery motors. A fourth transformer delivers current at 600 volts to an auxiliary-type power distribution switchboard. All four transformers are identical.

A 3-unit motor-generator set provides direct current for the adjustable-voltage cutter drive. This unit is made up of a 1,200-horsepower 900-rpm synchronous motor, an 800-kw 600-volt generator, and a 20-kw 125-volt d-c exciter.

Included in the electric equipment for the $5,500,000 dredge is a 200-horsepower 550-volt wound-rotor motor for the spud hoist, a 60-horsepower wound-rotor motor for both the auxiliary spud hoist and ladder hoist, adjustable-voltage d-c magnetic control for the hauling winch and ladder hoist, and a magnetic reversing a-c hoist control panel for the spud hoist.

Switchgear provided for the huge dredge is of the indoor, heavy-duty vertical-lift draw-out metal-clad type. It consists of a 1,200-horsepower synchronous motor starter, an 8,000-horsepower wound-rotor motor starter, a 600-kw transformer feeder, a 600-horsepower synchronous motor starter, a combination bus entrance and auxiliary compartment, and a set of metal-clad accessories.

The huge dredge was designed by the Ellicott Machine Corporation of Baltimore, Md.

The Beauharnois expansion program will keep the dredge operating 24 hours a day for $7^1/_2$ months a year for a period of 15 years. The power canal being dredged is designed to serve ultimately as a unit in the St. Lawrence Seaway Project, provision having been made in the plans for construction of a lock near the powerhouse. When the seaway is built, a width of 600 feet of the canal will be deepened to 27 feet as a ship channel.

Graduate Fellowships Offered by National Science Foundation

More than 700 students with special abilities in science will be selected for a year of graduate scientific study during the academic year 1954–55 in the National Science Foundation's Third Annual Graduate Fellowship Program. The closing dates for receipt of applications are December 15, 1953, for postdoctoral applicants and January 4, 1954, for graduate students working toward advanced degrees in science. The selections will be announced on or before April 1, 1954.

National Science Foundation fellowships are awarded to American citizens who will begin or continue their studies at the graduate level in the mathematical, physical, biological, medical, and engineering sciences during the 1954–55 academic year.

Selections will be made solely on the basis of ability. The majority of the fellowships will go to graduate students seeking masters or doctors degrees in science, although a limited number of awards will be made to postdoctoral applicants. Graduating college seniors in the sciences who desire to enter graduate school are encouraged to apply for the awards.

The rating system for selection of predoctoral fellows will be based on: (1) test scores of scientific aptitude and achievement; (2) academic records; (3) written evaluations of each individual from his faculty advisors and other qualified observers. Postdoctoral applicants will not be required to take the examinations. Applicants will be rated by special Fellowship Boards, established by the National Academy of Sciences. Final selection will be made by the National Science Foundation.

Stipends for National Science Foundation graduate fellowships will vary with the academic status of the fellows. First Year Fellows, students entering graduate school for the first time or those who have had less than 1 year of graduate study, will receive annual stipends of $1,400. Fellows who need one final academic year of training for the doctors degree will receive annual stipends of $1,800. Fellows between these groups will receive stipends at the rate of $1,600 annually. The stipends for postdoctoral fellows will be $3,400 per year. Dependency allowances will be made to all married fellows. Tuition and laboratory fees and limited travel allowances will also be provided.

National Science Foundation graduate fellows may attend any accredited nonprofit institution of higher education in the United States or similar institutions abroad.

Applications for the 1954–55 National Science Foundation Fellowship Program may be obtained from the Fellowship Office, National Research Council, Washington 25, D. C.

Contract Completed for First University-Owned Reactor

The North Carolina State College, Raleigh, of the University of North Carolina, and the Atomic Energy Commission (AEC) have signed an agreement which opens the way for immediate operation of the first university-owned nuclear reactor in the nation.

Through the contract, the AEC will loan North Carolina State College enough fissionable Uranium 235 to fuel the college's "Raleigh Research Reactor," recently constructed in a new building on the campus.

Provision of the fissionable material, or fuel, for the new reactor culminates a project which has been under way since June 1950 when the college, under contract to the AEC, initiated design and construction of a low-powered research reactor.

The building to house the reactor was completed at Raleigh in May 1953, with construction and assembly of the reactor's components finished since that time. The reactor assembly is now complete and most of the preoperational testing also has been completed. Loading of the fuel and initial operation of the reactor will begin as soon as the fissionable material is received from the AEC.

The reactor was designed and built completely with university funds available to the college and consequently is owned by the institution.

One of its major purposes will be to supply reactor experience to undergraduate and graduate students in nuclear engineering, a new curriculum initiated by the college in 1950. During the coming academic year, the college expects about 120 students to enroll in nuclear engineering. There were 110 students in this curriculum last year.

A program of research on the reactor itself is scheduled for the first year of its operation, after which the emphasis will shift to the use of radiations and radioactive isotopes produced by the reactor in numerous research activities of the college and neighboring institutions.

The reactor project is under the technical direction of Dr. Clifford K. Beck, who is also head of the college's Physics Department. Dr. Beck was associated with the atomic energy program from 1942 until 1949 when he accepted his present post. Working with Dr. Beck will be Dr. A. C. Menius and Dr. R. L. Murray, both of whom also were formerly connected with the federal atomic energy program.

North Carolina State was the first educational institution to approach the Commission with a proposal to design, build, and operate a research reactor and its proposal was the first one approved by the agency. Since that time, several other institutions have proposed similar projects which are under consideration by the AEC.

In making the fissionable material available to the college on loan, the Commission acted under the Atomic Energy Act of 1946, which permits the distribution of such materials for research and development activities, and for medical therapy.

Before approving the loan, the Commission assured itself that the reactor would be used in a well-planned research program. In operating the reactor, the college also must comply with certain health, safety, and security requirements established by the Commission.

The loan agreement will extend until June 30, 1954, and thereafter will be extended automatically on June 30 for an additional year, unless one of the parties notifies the other, before April 1 of any year, that it wishes to terminate the contract on the next June 30.

The Commission also may terminate the contract should national security considerations demand recall of the fissionable materials supplied under the agreement.

Industrial Hygiene Engineers Reduce Accidents and Time Lost

Last year, less than 1 man-hour was lost due to industrial ailments for every 100,000 man-hours worked by employees of the Westinghouse Electric Corporation. The credit for this must go to the industrial hygiene engineers and physicians.

The industrial hygiene operations staff at Westinghouse, which consists chiefly of laboratory technicians, chemists, engineers, and radioactivity specialists, maintains a card index of all the thousands of materials used by the company in manufacturing processes and personnel equipment. These indexed materials, which now number over 7,000, are carefully scrutinized for evidence of toxic qualities or other properties which may be harmful to the workman. Everything from goggles and protective clothing to paint thinners, solvents, and types of steel is carefully catalogued after being checked by either the industrial hygiene laboratory or the company's material engineers.

While research engineer works with a radioactive tracer, an industrial hygiene engineer measures radiation intensity with portable radiation counter. Metal badges on wrists of men contain special photographic films for recording radiation exposure

Dust particles taken from survey air sample are observed on a microprojection screen after magnification up to as much as 100 times. Industrial hygiene engineer determines the number of particles per cubic foot of air

The hygiene laboratory studies all toxic processing materials, including soaps, hand creams, eye protection, and so forth. Some hand creams and soaps have been found to be irritating and some others have been found not to do a satisfactory job of cleaning the skin. By means of meters, chemical analyses, and plain scrubbing of dirty hands, the laboratory technicians have determined the percentage of scouring materials in the various soaps, their alkalinity, lathering qualities, water softening ability, and the presence of irritating substances.

A principal threat to health is the air, and hygienists constantly check it for harmful dusts. For this job, they use an electrostatic dust and fume sampler. This fume sampler sucks air into a small metal tube, electrically charges the dust particles, and hurls them to the walls of a grounded cylinder. The sample is then analyzed in the laboratory by the hygiene engineer. He magnifies the tiny dust particles to 1,000 times their actual size and projects them on a special screen for observation. If the dust concentration in the air is above a specified level, he recommends that special protective devices be installed. A ventilating hood is placed over the machine or the workman is required to wear a respirator if added ventilation is not practical.

A painstaking and thorough check of dust is made at each Westinghouse plant at set time intervals. Usually, dust is checked for three factors: composition, number of particles per cubic foot of air, and size of particles. At the same time, an evaluation is made of the dust or fumes around the worker's immediate area.

A good deal of the success of the industrial hygiene operations staff depends upon its engineering knowledge. It must be able to discover possible hazards and it also must be able to alleviate the new-found hazards. An example of the use of this engineering knowledge is found in the unloading process used for powdery flint, feldspar, and clay. To avoid difficulty with these powdery materials, a pneumatic conveyor which sucks up 6 to 8 tons of material in an hour was devised. The powder is stored in huge silos and, as a result, workmen are not exposed to excessive dust in the air.

To aid them in increasing their engineering knowledge and in reducing the number of accident hazards to the lowest possible minimum, Westinghouse hygiene engineers conduct numerous tests. Knowing that slips and falls account for approximately 25 per cent of all industrial accidents, they devised their own mechanism for testing the slipperiness of floor waxes. The device has a hinged leg which extends to the floor and a leather or felt boot at the end of the leg which measures 2 square inches in area—the approximate size of the heel of a woman's shoe. A downward pressure of only 20 pounds is needed to simulate the weight of a person. The end of the leg is moved outward along the waxed surface to a point where it will slip or give way completely. By measuring the distance the boot traveled before slipping, the testers are able to tell how easily a person may slide on the wax.

With more and more plants making use of machines that utilize atomic energy, hygienists continually must enlarge their scope of operations where radiation is concerned. Using knowledge gained from a study of the effects of atomic radiation and methods of measuring radiation intensity at the atomic plant at Oak Ridge, hygiene engineers maintain a constant check for preventing physical harm resulting from the use of radioactive isotopes and X-ray machines employed at the various Westinghouse locations. Special steps are taken to make certain that employees do not breathe radioactive dust or fumes and that the skin or other parts of the body are not affected by radiation from radioactive sources.

While searching for radiation effects, personnel are equipped with the latest detection devices such as geiger counters, ionization chambers, special film badges, and electrometers.

While all hazards have not as yet been eliminated, accidents and time lost have been reduced significantly by the industrial hygiene departments.

Westinghouse D-C Arc Welder Offers Many Advantages

Reductions in size and weight, and increases in ease of maintenance and user and operator convenience are the principal added advantages of a new Westinghouse selenium rectifier d-c arc welder. A result of a 4-year development program, this new welder additionally incorporates all the characteristic advantages of the selenium-rectifier-type welder: high efficiency with low no-load losses; a-c welding performance with d-c welding characteristics; and high dependability with low maintenance due to an almost complete lack of moving parts.

The heart of the welder consists essentially of two parts: a 3-phase full-wave selenium rectifier and a so-called Transactor unit, which is a combination 3-phase transformer and movable core reactor, which has two 3-phase laminated cores. One is a fixed core on which the primary and secondary coils are wound. The other is divided into two parts, a stationary core, and a movable core. The legs of the movable core are linked by the common secondary and reactor winding.

Current is controlled by means of a hand crank on top of the welder which moves the movable core section in relation to the Transactor unit coils. The Transactor unit coils, for the first time in any welder, are aluminum. Through proper design, Class *B* insulated aluminum conductors produce operating characteristics equal to copper coils and reduce coil weight by one-half.

An exclusive control feature—Arc Drive Control—eliminates arc short circuits during welding applications requiring a short arc. Arc Drive Control supplies instantaneous current surges when the arc begins to short-circuit out, thereby clearing the short circuit and re-establishing the arc.

Although the three standard sizes of this new welder are 200, 300, and 400 amperes, Duplex models are available in 300/600- and 400/800-ampere ratings.

Light's Diamond Jubilee Emblem Adopted by Industry Committee

An emblem for Light's Diamond Jubilee, the 1954 celebration of the 75th anniversary of Edison's invention of the first practical incandescent lamp, has been adopted by Light's Diamond Jubilee Committee, it was announced recently.

The face of the emblem shows Edison's first incandescent lamp bulb held against the atomic symbol. This representation symbolizes both past and future practical applications of electricity, which is the theme of the Jubilee celebration.

The reverse of the emblem gives the Jubilee slogan, "Light for Freedom—Power for Progress" which epitomizes the role of electricity today. A short text, "Commemorating Thomas A. Edison's invention of the first practical incandescent lamp October 21, 1879," defines the event being celebrated in Light's Diamond Jubilee. A laurel branch on the reverse of the emblem symbolizes achievements made possible by electricity in the past 75 years.

Light's Diamond Jubilee Committee, which is composed of representatives from all segments of the electrical industry, will coordinate industry-wide activities in the celebration of the Jubilee next year.

Weather Maps Transmitted by Facsimile in New System

The Meteorological Service of the Department of Transport of the Dominion of Canada has inaugurated a new facsimile system for the transmission of weather maps by land wire and wireless to all parts of Canada and even into the far north. The scope of this new system will cover more than 4,000 miles of land wires and more than 1,500 miles by radio in the matter of a few minutes.

By means of this new system it is expected that there will be greater efficiency and economy in operations, greater accuracy in weather charting, and a saving in meteorological manpower. Actively associated with the Department in this achievement are the Royal Canadian Air Force (RCAF), and the two telegraph companies, the Canadian National and the Canadian Pacific.

The Canadian Weatherfax System, as this new weather map transmission service is being called, is the first fully automatic system of its kind in the world. The special features of the equipment, the stopping, starting, and phasing of the recorders at the different receiving stations, are all controlled remotely from the transmitting station, possibly hundreds of miles away. The receiving stations are required only to keep power supplied to the recorders and a roll of paper in the machine.

Another feature is that the maps or pictures transmitted come out of the recorders fully printed and do not require any laboratory processing, thereby greatly speeding up the service.

This Weatherfax communications system will permit weather maps to be drawn centrally by a specially trained group at Dorval, Quebec, and to be transmitted to RCAF stations across Canada. Thus, each Air Force station will have complete weather maps covering all levels from the surface to 50,000 feet.

Without the Weatherfax System it would be tremendously expensive to provide this kind of service independently at each of the Air Force stations. In fact, from a manpower standpoint it would be impossible, because of the number of meteorologists needed

Emblem adopted for celebration of Light's Diamond Jubilee

in Canada to provide the large staffs of professional men that would be required at every Air Force station to make such a complete analysis of the upper air. Thus, in effect, the Weatherfax System makes possible a service to Canadian national defense that could not be given in any other way: a service which is essential for a modern air force.

When in full operation, the Weatherfax System will combine national and regional transmissions. The Central Analysis Office at Dorval will transmit every 6 hours a complete series of weather maps and associated charts and diagrams. This transmission will be so arranged that all stations in Canada will receive these centrally prepared charts simultaneously.

The system can be broken down into regional networks so that each of the main district forecast offices at Vancouver, Edmonton, Winnipeg, Malton, Dorval, and Moncton, will be able to send supplementary material of regional significance to stations in their districts. This flexibility in operations will result in further efficiency and economy.

The radio facsimile circuit to Frobisher, in the Arctic, is, technically, another first for Canadian communication engineers. The signals being fed to the land-line Weatherfax System across Canada will go, electronically, straight on to the powerful transmitters in Montreal for transmission to Goose Bay, Labrador, and, again electronically, without human aid or action of any sort, will be transposed and put on another radio transmitter at Goose Bay, where they will be relayed on the circuit already established to Frobisher. Thus Frobisher will receive the charts at the same time as Vancouver, Moncton, and Goose Bay.

The Weatherfax System has a great civilian potential in bringing meteorological services to civil aviation and other weather-sensitive activities across Canada to an extent and with an economy heretofore impossible. The civilian expansion of the development of this facility, of course, will have to wait until the urgent military demands have been met: but it is always a source of satisfaction when expenditures brought about by military necessity can and ultimately will be used to the advantage of civilian services.

New Method for Designing Transformers Developed

A new method for designing electric transformers that promises to help relieve the shortage of engineers has been worked out by research men at Armour Research Foundation of Illinois Institute of Technology, Chicago.

The method, conceived by Dr. David E. Wiegand, senior physicist, and Harold L. Garbarino, associate electrical engineer, simplifies transformer design to the use of an alignment chart, or "nomograph," and some standardized equations.

The new system was created especially for design of electronic power supplies, Dr. Wiegand said, but it can be adapted to design of other types of transformers as well.

Explaining the value of their system, the two research men said that designing transformers has been a fairly complicated process requiring an experienced design engineer. However, inexperienced men can design transformers with the new method, leaving experienced design engineers free to work on more important jobs. This, Dr. Wiegand and Mr. Garbarino agree, is the new system's principal advantage.

They add that the design reached through use of the system turns out to be very nearly the best design possible from the standpoints of size, weight, and economy of materials. It comes out that way because equations can not take account of human experience.

According to Mr. Garbarino, trials have shown that the amount of time saved by using the new method is remarkable. An inexperienced man can master the method in as little as 8 hours.

Several large manufacturers of electric equipment have evaluated the design method in their engineering departments. In one case, a technician, an inexperienced engineer, and an experienced engineer were assigned to test the method. They all used the new method, and all arrived at similar practical designs. Other groups have reported similar experiences.

In addition to its other virtues, the method is said to help industry turn out more uniform transformers. It tends to iron out individual tendencies of designers, giving a more standardized product.

The new method for designing transformers was worked out as part of a research project at Armour Research Foundation sponsored by the United States Army Signal Corps.

Grants-in-Aid Will Help Further College Training

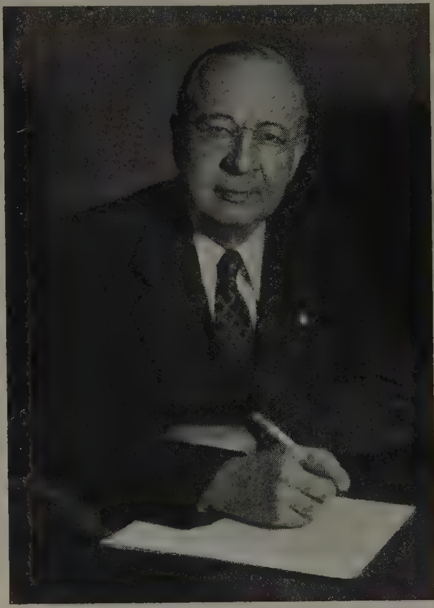
A program of financial assistance to help working engineers and technical personnel to further their college educations by graduate study has been made public by C. F. Adams, Jr., president of Raytheon Manufacturing Company, Waltham, Mass.

"Each year several hundred members of the Raytheon staff register for evening courses of study in engineering and science at local universities," declared Mr. Adams, "with the express purpose of improving the extent of their knowledge in their chosen fields of specialization or in allied fields."

Recognizing that this additional study makes the men more valuable in their work, the electronics firm's management has adopted a policy of tuition support called "The Raytheon Grant Plan," directed primarily to encourage graduate study by engineering and scientific employees. Aid also may be available to the company's accountants, lawyers, and other professional people in special circumstances. The plan sets forth a set of simple rules for eligibility, stating briefly that (1) an engineer must be employed by the company in an engineering or research capacity; (2) he must not be receiving educational assistance under the G.I. Bill nor under a scholarship or grant from a college or university; (3) must be enrolled in an evening course in science or engineering at the undergraduate or graduate level, or in certain equivalent programs; and (4) must submit an application prior to the first day of November, February, April, or July for the quarterly periods beginning shortly thereafter.

Dr. Steinman Honored at Testimonial Dinner

Dr. David B. Steinman, New York consulting engineer, was honored at a testimonial dinner on October 2, 1953, at Bear Mountain, N. Y., during the autumn meeting of the New York State Society of Professional Engineers. The dinner was in recognition of Dr. Steinman's 24 years' service as a member of the New York State Board of Examiners for Professional Engineers and Land Surveyors. Dr. Steinman was appointed to the board in 1929 and has served continuously as a member and part of that time as chairman until his resignation on July 1, 1953.


Dr. David B. Steinman who was honored at a testimonial dinner by the New York State Board of Examiners for Professional Engineers and Land Surveyors

Dr. Steinman holds the degrees of civil engineer and doctor of philosophy from Columbia University and also several other honorary degrees. He is a professional engineer and a registered architect. Dr. Steinman is a founder and a past president of the New York State Society of Professional Engineers. He played a prominent part in the organization of the National Society of Professional Engineers and served as its first president. Dr. Steinman will be replaced on the board by James F. Fairman (F '35).

Dr. Steinman, who is a bridge engineer, received a scroll citing him for his 24 years of service as a member of the board and 9 years as chairman.

High-Precision Printed Circuit Automaton Developed

A significant step in the direction of the completely automatic electronics factory has been taken with the development by engineers of Emerson Radio and Phonograph Corporation of a fully automatic component adjusting machine, the "Autobrader," which insures faster and more accurate production of printed electronic circuits, it was announced recently by Dorman D. Israel, Emerson's executive vice-president.

For the first time, Mr. Israel stated, high-precision printed components can be produced on a completely automatic basis by the revolutionary new machine, with an accuracy and saving of time hitherto unavailable.

The Autobrader automatically abrades away resistor and capacitor material from printed circuit units to standardize their value to the precise point required by electronic designers. In a matter of split seconds, Mr. Israel explained, Emerson's Autobrader feeds itself with a part to be worked on, examines it to assure its suitability for adjustment, discarding it if unsuitable, adjusts it to precise value if usable, conducts a final inspection operation, and then again sorts good from bad pieces. Manual labor is required only for loading of a supply chute and for removal of completed work.

Mr. Israel pointed out that most of the other techniques used for resistor "tailoring" rely on the removal of resistor material by hand erasure, abrasion, and other methods. These techniques require the skilled preselection of resistor units to ascertain suitability for abrasion, subsequent abrasion by trained operators to the desired point of resistance, and reinspection for value—each requiring handling operations as intermediate steps. The completely automatic aspect of the Emerson invention eliminates the considerable number of rejects which are an inevitable result of human handling of the assembly, yields a more uniform product, and reduces manufacturing cost.

Emerson's machine is the latest development in the new science, "Automation," in which engineers combine standard machines and instruments with special electronic controlling brains and handling units. The Autobrader goes further than most of these devices since it performs its own inspection in addition to achieving high-speed production. Emerson engineers believe that radio, television, and electronic equipment of the future will rely heavily upon Automation, to which the Autobrader represents a major contribution.

Turntable Radar Set Eliminates Necessity of Moving Sets

Effective use of the Ground Controlled Approach System (GCA), famed radar device for finding, then guiding aircraft and crews to safe landings under conditions of zero visibility, will increase with the development of a new rotating base for standard GCA sets, the United States Air Force's Air Research and Development Command announced recently.

Called the Turntable Radar Set, the rotating mount will provide Air Force units with single-site ground-controlled approach facilities, eliminating the necessity of moving radar sets from one position to another each time the direction of landing aircraft is changed due to wind variations.

The device, developed by The Air Research and Development Command's Rome Air Development Center, Rome, N. Y., with Craig Machine, Inc., of Danvers, Mass., is calibrated when installed to align itself automatically to the appropriate runway at the push of a control button in $3^1/_2$ minutes.

The ring of the Turntable Radar Set is shown during assembly. It can be rotated 340 degrees at the push of a control button

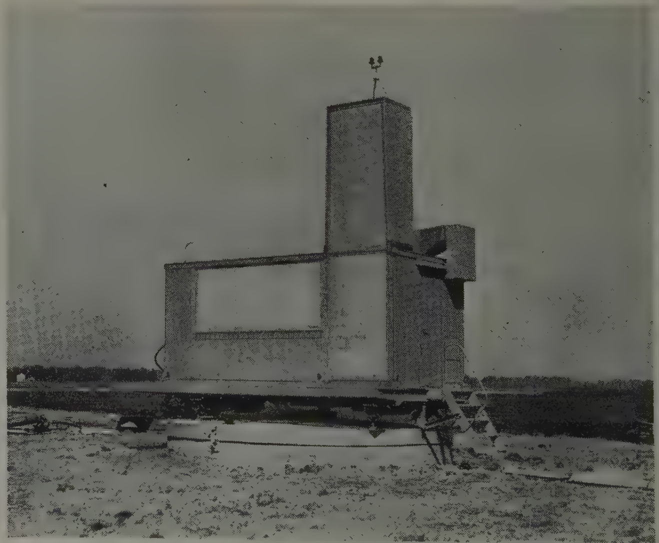
The turntable enables an air base to provide ground-controlled approach facilities on multiple runways in both directions with only one radar set and from a single site. It can be used for: 1. multiple runway coverage by rotating the turntable to align with the various runways; 2. turn-about operation and to give bidirectional coverage (left and right) of a runway; 3. simultaneous monitoring on parallel runways of take-offs and double landings; 4. straight-in approaches for emergency landings which must disregard runways.

The turntable consists essentially of a rectangular platform mounted on a ring which is supported by rollers on the concrete foundation. The platform and the ring each can be leveled independently of the other.

When mounted on the turntable, an *AN/FPN-16* precision approach radar can be rotated through 340 degrees in $3^1/_2$ minutes, making the instrument runway usable from either direction. In the past, approximately a half hour was required to move a radar set from one runway position to another.

The cost of the Turntable Radar Set is a small fraction of the cost of additional sets, vaults, and underground circuits, which otherwise would be required to give equivalent GCA coverage.

The original model is installed and in operation at the Rome Air Development Center. Additional sets are now in production for use at several key Air Force bases.



The assembled turntable and shelter can be turned automatically from one runway coverage to another in less than $3^1/_2$ minutes

Electronic Computer Operated by Long-Line Remote Control

In what was probably the first attempt at long-line remote control of an electronic "brain," Burroughs Corporation recently established a direct, telegraphic link-up between Wayne University in Detroit, Mich., and Burroughs' Research Center in Philadelphia, Pa., a distance of over 500 miles.

Wayne operated the Burroughs Laboratory Computer during a special 2-week course on automatic digital computers. Students, with the assistance of Wayne's laboratory staff, fed highly complicated mathematical problems of business and science directly into the computer by means of a teletype coded-tape sending machine. Answers were sped back from the Philadelphia laboratory and the actual figures recorded by teletype printer in Detroit.

Three areas of computer study were planned for students attending the course. One group concentrated on business applications, while another group studied and experimented with engineering and scientific applications. The third group dwelt on the technicalities of computer construction and component parts.

Wayne University purchased this electronic computer from Burroughs and it now is being assembled at the Detroit institution.

Slice-Away Battery Assemblies Designed for Transistor Use

Two types of alkaline battery assemblies which can be sliced, like a package of candy mints, into numerous combinations of cells to provide different voltage requirements were announced recently by the Tube Department of the RCA Victor Division, Radio Corporation of America.

The unusual battery assemblies are intended specifically for equipment designers and experimenters exploring application possibilities of transistors.

These battery assemblies are expected to facilitate transistor-circuit experiments because they permit rapid assembly of power supplies not readily available in standard commercial batteries.

Both RCA "slice-away" battery assemblies are 21-volt special-purpose types. Each contains 15 individual 1.4-volt crown-type alkaline dry cells firmly encased in a plastic sleeve. Each cell is indicated by a pair of ridges which are formed in the plastic sleeve by the scalloped edges of the metal caps of the cell. Various power requirements, from 1.4 to 21 volts, can be obtained quickly by slicing a section of the battery containing the necessary number of cells. Slicing of the battery assemblies can be accomplished easily with an ordinary knife or a razor blade.

The importance of slice-away battery assemblies is that they provide designers and experimenters with a flexible power supply that can be modified to meet the design problem of the moment. Transistors are basically low-power electron devices, and the circuits which employ them have different drains and require different voltage supplies. A requirement, say, for 7 volts can be met quickly by slicing five cells from the battery stack.

Graphical Methods Conference to Be Held in November

Methods of applying graphics to engineering problems in order to save time and present data more effectively will be outlined in a conference at Purdue University on November 20, 1953. This is one of the first conferences on graphical methods application that ever has been held.

Engineering executives of representative Indiana industries are co-operating with university staff members in planning an informative program designed to acquaint chief engineers, directors of research, and others of comparable executive level with the scope of graphical methods. It is hoped to show how these methods can contribute to the increased efficiency and effectiveness of designers and draftsmen employed in various industries.

"As a means of counteracting high production costs and manpower shortages in industry today, graphical methods often save man-hours of work in arriving at an answer to a problem, and usually give a clearer and more meaningful picture of the information being presented or studied," according to Professor J. Howard Porsch, chairman of the engineering drawing section of the Department of General Engineering at Purdue, who has been designated chairman of the conference.

The 1-day program will include an introduction to graphics, and discussions of delineation, analogous representation, problem solutions, mechanical devices, and reproduction processes. Each of the talks will be followed by a discussion period. An exhibit of graphical method techniques is planned also.

The conference will show the application of graphical methods to engineering design and manufacturing. Professor Porsch emphasized that this first meeting is designed primarily for management-level engineering personnel.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ASTM STANDARDS ON ELECTRICAL INSULATING MATERIALS. Prepared by ASTM Committee *D-9* on Electrical Insulating Materials. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 573 pages, 9 by 6 inches, paper. $5.25. The current edition of this annual compilation contains in their latest approved form 75 specifications, test methods, and recommended practices broadly classified as follows: insulating shellac and varnish; sheets, tubes, and molded materials; mineral oils; ceramic insulators; insulating papers and fabrics; mica; plastics; and electrical tests.

CIRCUIT THEORY OF ELECTRON DEVICES. By E. Milton Boone. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 483 pages. $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8.50. This text covers linear circuit theory of tubes and transistors with emphasis on the analysis of the circuit properties of the devices, properties that can be determined by measurements at available terminals. A feature of the book is the utilization of the concepts of 4-terminal networks in sufficiently general form to apply to any electron device over any frequency range in which the device operates within the linear region of its characteristic.

COUNTY AND CITY DATA BOOK 1952. (A Statistical Abstract Supplement.) United States Bureau of the Census. Obtainable from Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., 1953. 608 pages, $11^{3}/_{4}$ by $9^{1}/_{4}$ inches, bound. $4.25. Planned to meet the need for summary information on the smaller geographical and political entities in the country, this volume assembles data for each county, standard metropolitan area, state, and geographic division, and for each of 484 cities having 25,000 or more inhabitants in 1950. Subjects covered by the statistics given include population, vital statistics, housing, retail trade, construction activity, electric energy consumption, and so forth, mainly based on the 1950 Census.

ELECTRON OPTICS. By O. Klemperer. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., second edition, 1953. 471 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $9.50. This monograph gives an account of the principles, methods, and applications of geometrical electron optics. It serves two purposes: to introduce the student to a specialized subject, and to present the research worker or designer of electron optical gear with detailed working principles and essential information and to guide him to the extensive literature on the subject. Some 500 papers are cited.

ELECTRONIC CIRCUITRY FOR INSTRUMENTS AND EQUIPMENT. By Milton H. Aronson. Instruments Publishing Company, 921 Ridge Avenue, Pittsburgh 12, Pa., 1953. 310 pages, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound. $4. A nonmathematical presentation of basic circuits and fundamental techniques with examples and applications covering a broad scope. The author first considers such characteristics as resistance, capacitance, inductance, and signal shaping. He then deals with vacuum-tube and gas-tube fundamentals, followed by amplification, rectification, and oscillation circuits including a variety of instruments and types of equipment.

ELEKTRISCHE SCHALTVORGANGE. By Reinhold Rüdenberg. Springer-Verlag, Berlin, Germany, fourth edition, 1953. 599 pages, 10 by 7 inches, bound. DM 67.50. A detailed treatment of transient phenomena in closed circuits of electric power systems. It includes thoroughly revised treatments of Sections *A* and *B* of the previous edition dealing respectively with lumped linear circuits and performance of circuits with nonlinear characteristics. A separate book is planned to deal with the former Part *C:* traveling waves on electric circuits.

HOCHSPANNUNGSGERATE UND -SCHALTANLAGEN. By Heinrich Probst. Verlag und Druck G. Braun, Karlsruhe, Germany, 1953. 196 pages, $8^{1}/_{2}$ by 6 inches, bound. DM 20. An account of the evolutionary development of the various forms of high-voltage equipment and switchgear from their beginnings up to 1950 both in Germany and in other countries. The aim of the book is not primarily historical, but rather to show how designs which at one time are wrong with change of circumstances may become right. It covers current supply, switching equipment, switchboard attendance, and switchgear planning.

AN INTRODUCTION TO SCIENTIFIC RESEARCH. By E. Bright Wilson, Jr. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 375 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6. A book of practical suggestions for planning and carrying out scientific research, intended for students beginning research and for the experienced research worker with little training in methods of investigation. Principles and procedures applicable to a wide range of sciences rather than to a specific science are presented in the order in which they arise in research. Apparatus design and data analysis are given the fullest treatment.

KERNEL FUNCTIONS AND ELLIPTIC DIFFERENTIAL EQUATIONS IN MATHEMATICAL PHYSICS. By Stefan Bergman and M. Schiffer. Academic Press, Inc., 125 East 23d Street, New York 10, N. Y., 1953. 432 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8. The subject of this book is the theory of boundary value problems in partial differential equations. This theory plays a considerable role in various fields of physics and engineering, as indicated by the chapter headings of Part *A:* Theory of heat conduction; fluid dynamics; electro- and magnetostatics; elasticity. Although the physical significance is studied, the approach is primarily mathematical and a systematic treatment is followed without simplification.

MESSUNG DER UBERTRAGUNGSEIGENSCHAFTEN VON TELEPHONEN, MIKROPHONEN UND FERNSPRECHERN. By Martin Gosewinkel. Verlag und Druck G. Braun, Karlsruhe, Germany, 1953. 160 pages, $8^{3}/_{4}$ by 6 inches, bound. DM 19. A reference book for the field testing, factory inspection, and acceptance testing of the transmission characteristics of telephone earphones, microphones, and subscribers' sets. In addition to the general treatment there are detailed descriptions of specialized types of testing equipment.

SYMPOSIUM ON EXCHANGE PHENOMENA IN SOILS. (Special Technical Publication Number *142*) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 74 pages, 9 by 6 inches, paper. $1.75. Five articles are included which deal with related aspects of this field of soil physico-chemistry. They deal with basic phenomena leading to methods by which soils are altered to achieve adequate engineering performance even under adverse circumstances. Both generalities and specific data are provided.

TABLE OF ARCTAN x. (Applied Mathematics Series, Number *26*) National Bureau of Standards. Available from Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., 1953. 170 pages, $10^{1}/_{2}$ by 8 inches, bound. $1.75. This is the first contribution to what is intended to be a complete set of tables of the inverse trigonometric and hyperbolic functions, a useful tool in a variety of applications. The tabulation is to 12 decimal places over a range of x from 0 to 10,000 with intervals ranging from 0.001 to 10.

TABLES FOR ROCKET AND COMET ORBITS. (Applied Mathematics Series, Number *20*) By Samuel Herrick. National Bureau of Standards, available from Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., 1953. 100 pages, $10^{1}/_{2}$ by 8 inches, bound. $1.75. The anticipated development of rocket navigation has directed serious attention to rectilinear motion in the 2-body problem. For rectilinear orbits these tables make it possible to determine position and velocity from the time. They also may be used for the so-called "nearly parabolic" orbits.

ASTM MANUAL ON MEASUREMENT AND SAMPLING OF PETROLEUM AND PETROLEUM PRODUCTS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 133 pages, 9 by 6 inches, paper. $1.50. This compilation, presenting the standard practices most widely used today, provides detailed methods for measuring and computing oil in storage tanks of various types and for getting typical samples. Each section of the book—gauging, temperature measurement, volume calculations, water and sediment, gravity, sampling—includes special instructions and precautions as well as the essential data.

TRAFFIC MANAGEMENT IN INDUSTRY. By Leslie A. Bryan. Dryden Press, 31 West 54th Street, New York 19, N. Y., 1953. 452 pages, $9^{1}/_{2}$ by $6^{1}/_{2}$ inches, bound. $5.50. The opening chapter serves as a general orientation to industrial traffic management. Succeeding chapters describe the general functions of a traffic department, its organization, personnel, and administration. There are detailed discussions of specific duties in connection with rates, expediting, intraplant transportation, materials handling, and so forth. Forms and legal aspects also are covered.

EQUIPMENT FOR THE THERMAL TREATMENT OF NON-FERROUS METALS AND ALLOYS. (Monograph and Report Series, Number 14.) The Institute of Metals, London, England, 1953. 104 pages, $11^{1}/_{4}$ by $8^{3}/_{4}$ inches, bound. $2.50. The seven papers in this symposium deal with the following topics: electric furnaces; gas equipment for heat treatment; batch and continuous annealing of copper and copper alloys; bright annealing of nickel and its alloys; batch heat treatment of light alloys; flash annealing of light alloys; and continuous heat treatment of aluminum alloys of the Duralumin type. There is a general subject index covering all the papers.

DIE HOCHSPANNUNGS-FREILEITUNGEN. By Karl Girkmann and Erwin Königshofer. Springer-Verlag, Vienna, Austria, second edition, 1952. 655 pages, $9^{3}/_{4}$ by 7 inches, bound. $22. Intended for both the student and the practicing engineer, this treatise presents in detail the latest practice in high-tension overhead lines in Germany and abroad. It opens with a section on the structural elements of overhead lines; discusses design calculations of long-distance power transmission; and covers conductors, insulators, armatures, and so forth. A large part of the book is devoted to tower design, construction, erection, and foundation work. There are separate chapters on preliminary work on the terrain, assembly of the line, operational problems, and communication transmission over the high-tension system.

COMMUNICATION THEORY. Edited by Willis Jackson. Academic Press, Inc., 125 East 23d Street, New York 10, N. Y., 1953. 532 pages, 10 by $6^{1}/_{2}$ inches, bound. $11. A symposium of specialized lectures discussing various aspects of the practical value of "information theory" in the problems of electrical communication. An introductory chapter provides a brief survey of communication theory comprising both the "signal analysis" and the statistical theory. Subsequent chapters cover transmission systems and coding, transmission in the presence of noise-signal discrimination, characteristics of transmission channels, applications to television, and transmission and analysis of speech. A concluding discussion serves as a review of the symposium.

DIELECTRIC AERIALS. (Methuen's Monographs on Physical Subjects). By D. G. Kiely. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 132 pages, $6^{3}/_{4}$ by $4^{1}/_{4}$ inches, bound. $2. The object of this small monograph is to provide a critical review of existing work on this type of microwave aerial and to collect design data. The author sets out three different methods of analytical approach to the problem, dealing with dielectric rod aerials, dielectric tube aerials, and other miscellaneous types.

DIESEL ENGINEERING HANDBOOK. 1953 edition. A. B. Newell, editor. Diesel Publications, Inc., 192 Lexington Avenue, New York 16, N. Y., eighth edition, 1953. 827 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7.50. As in the previous editions detailed information is given on the diesel cycle, fuels, engine components, and auxiliary equipment, including some specialized topics such as dual-fuel engines. In this new edition there is a brief chapter on marine diesels and a new section also has been added describing representative American makes and types, with tabulated up-to-date specifications of all makes and models.

ELECTRIC ARC WELDING. By John Benjamin Austin. American Technical Society, 848 East 58th Street, Chicago 37, Ill., 1953. 280 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $4. A comprehensive treatment of the fundamentals and latest techniques of electric arc welding, the equipment used, and applications in the major fields of welding: hard surfacing, and pipe, machinery, and structural welding. One chapter is devoted to special automatic metal-arc processes, and another describes the common methods of testing welds. The codes used in the various industries are indicated throughout the text.

EXPERIMENTAL NUCLEAR PHYSICS, VOLUME II. E. Segrè, editor. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 600 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $12. This is the second of a 3-volume work on the experimental techniques and theoretical interpretation of the data in nuclear physics. It includes a treatise on nuclear reactions and an extensive discussion of the properties, sources, detection, and interactions of the neutron. Each treatise with its accompanying bibliography provides the reader with the main results obtained in nuclear physics up to the end of 1952.

FIELDS AND WAVES IN MODERN RADIO. By Simon Ramo and John R. Whinnery. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1953. 576 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8. The electromagnetic theory essential to an understanding of the subject is fully treated at an intermediate level. This second edition contains much new material, including an entirely new chapter on microwave networks, new developments on slow-wave guiding structures and other miscellaneous guiding systems, and various recent developments concerning horns, slot antennas, and receiving antennas.

50–100 BINOMIAL TABLES. By Harry G. Romig. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 172 pages, $8^{3}/_{4}$ by $7^{1}/_{4}$ inches, bound. $4. This volume gives the tables for positive binomial $(q+p)^n$ where $q=1-p$, and covers the range of n values from 50 to 100 in steps of 5 and the range of p values from 0.01 to 0.99 in steps of 0.01. Directions for the use of the tables, including a brief discussion of interpolation, indicate their many possible uses especially in the field of quality control.

FUNDAMENTALS OF ELECTRONIC MOTION. By Willis W. Harman. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 319 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.50. This text, utilizing electron-tube analysis as a teaching medium, is intended primarily to stimulate and further an ability to cope with new problems and situations. It covers field distributions, electron motion in magnetic fields, electron optics, static space-charge problems, motion in time-varying fields, the traveling-wave, and various standard recent practical applications of these concepts.

INFORMATION THEORY: AND ITS ENGINEERING APPLICATIONS. By D. A. Bell. Sir Isaac Pitman and Sons, Ltd., London, England, 1953. 138 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 20s. The chief aim of this book is to make available to the "professional engineer" in telecommunications and allied work the substance of developments since 1948 in the theory of the performance of communication systems. Chapters deal with the binary digit measure, entropy and information, signalling speed, signal-to-noise ratio, coding, and practical applications, some actual and some hypothetical.

AN INTRODUCTION TO POWER SYSTEM ANALYSIS. By Frederick S. Rothe. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 187 pages, $9^{1}/_{4}$ by 6 inches, bound. $5. A brief account of fundamentals considering the characteristics of the generator, transformer, transmission line, and load. The author covers only those problems associated with the fundamental operating frequency, at the same time thoroughly investigating the transient behavior of the components during disturbances. Worked problems are included.

LABORATORY INSTRUMENTS. Their Design and Application. By A. Elliott and J. Home Dickson. Chemical Publishing Company, Inc., 212 Fifth Avenue, New York, N. Y., 1953. 414 pages, $8^{3}/_{4}$ by 6 inches, bound. $7.50. The chief aim of this book is to provide the research worker with the principles of good design necessary for the construction of instruments in the laboratory workshop. Separate chapters discuss the properties, treatment, and use of various materials; methods of construction to meet special requirements; kinematic design of instruments; sensitivity and disturbing influences; the considerable subject of optical instruments and optical glass; and the use of photography in research.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Scientific Manpower. An annotated and selected bibliography has been compiled from reports of scientific institutions to show to what extent scientific manpower is utilized to the best interests of the nation. Because the problem of scientific and technical manpower resources is of paramount importance today, this volume, prepared by the Research and Development Board, Department of Defense, is available to all. In it are discussed current and future sources of scientific personnel, the increase and decrease in the number of scientists over the years, the distribution of scholars in various fields of science, the rise and fall of supply and demand, and occupational mobility among the scientists. The report also shows how research organizations both in government service and in private industry maintain a reservoir of manpower in the varied fields of the physical and social sciences. 30 pages. 50¢. Available from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Conditioning and Weathering. This symposium on weathering and conditioning was sponsored by the American Society for Testing Materials to promote an expanded understanding of the importance of conditioning and weathering in the assessment of our materials of engineering and to encourage further effort to utilize controlled atmospheric phenomena in laboratory procedures. Papers covered effects of conditioning on paper, adhesives, plastics, organic coatings, metallic coatings. 104 pages. $2.25. Obtainable from American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Inert-Gas-Shielded Metal-Arc Welding Process. The pamphlet covers the lectures on the fundamentals on the inert-gas-shielded metal-arc welding process presented at the annual meeting of the American Welding Society. The characteristics of the inert-gas-shielded metal arc and the mode of metal transfer are illustrated and explained. The effect of variables on the operation of the equipment in all positions of welding is demonstrated. 30 pages. $1.00. Copies may be obtained from the American Welding Society, 33 West 39th Street, New York 18, N. Y.

Guide for Receiving Tubes. A guide to Reliatron receiving tubes contains characteristics and ratings of over 300 tube types. The ready guide has been designed for ease of use; tube symbols are interpreted easily and are associated closely with their tabular information. Tabulations are presented in a legible style. 47 pages. 35¢. Order from Westinghouse Electronic Tube Division, Department T-329, Box 284, Elmira, N. Y.

Heavy duty *in every inch of it*

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MOTORS

Have you a tough drive like a ball mill, pulp grinder, wood chipper, or anything else that takes real stamina to keep going dependably? Here's the motor for it — this big, husky Elliott slow-speed synchronous motor, with all the crack-proof strength and enduring rigidity of heavy welded steel, in base, bearing support, rotor and frame. It's the way Elliott builds big motors, and it's setting new records everywhere in performance as well as popularity.

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R3-8

How Burndy Limiters Isolate Faulted Cables and Prevent Extensive Damage in Underground Secondary Networks

by IRVING MATTHYSSE *Chief Design Engineer, Burndy Engineering Company*

Prompt, selective clearing of severe electrical faults in underground secondary cables is of utmost importance in preventing extended loss of service to customers, the possibility of explosion and fire as well as expensive replacement and repair. Reliance on system capacity alone to burn faults clear is dangerous as it obviously gives faults greater leeway to "hang on", to spread, to cause "roasting" of cable insulation and destroy hundreds or even thousands of feet of cable before cutting crews can arrive on the scene.

It is for this reason that an ever increasing proportion of utilities are using Burndy Limiters in their secondary systems. These limiters are expressly designed to clear short circuit currents quickly, although the time-current characteristics of the device are such that normal electrical overloads—which will not harm the insulation of the cable—can be carried for long periods of time.

The Burndy Limiter basically is a combination fuse and cable connector, rated in terms of voltage and cable size, according to the cable which it is designed to protect. (Time-current characteristic curves are shown on opposite page).

Let us see how the Limiter functions under typical fault conditions:

Referring to Fig. 1, we see a typical AC secondary network system with one of the 3 phases shown. For clarity, this has been somewhat simplified. It is apparent that a network is essentially a grid (in practice often conforming to the pattern of the city's streets) inter-connected at all junctions. Power is fed into certain junctions of the secondary mains (usually 220 volts) by means of transformers which convert the voltages from incoming primaries or high voltage feeders (usually 4,160 volts or higher). Limiters are shown at junction B.

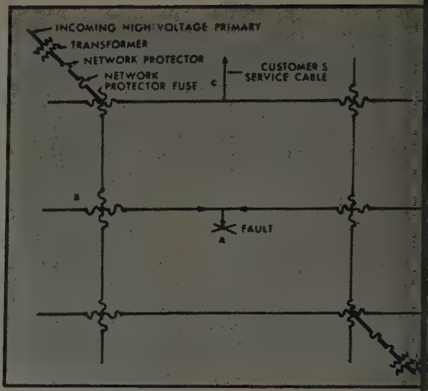


Fig. 1—Typical AC Secondary Network

Assume that the fault occurs at poi
A, Fig. 1. Current is supplied to the fau
via junction B through the Limiter in th
faulted cable. The fault current at jun
tion B is divided among the other 3 Lim
iters, and it follows that the Limiter

UNDER

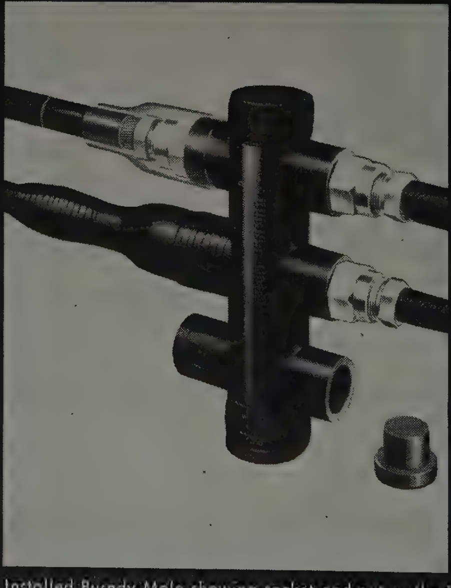
FOR SOUND,
QUICK CONNECTIONS
...ECONOMICAL EXPANSION

Burndy Moles have multiple outlets, from 2 to 18 per unit, permitting reserves for future use. Each outlet will take a range of cable sizes. Easy interconnection of Moles permits great flexibility of expansion.

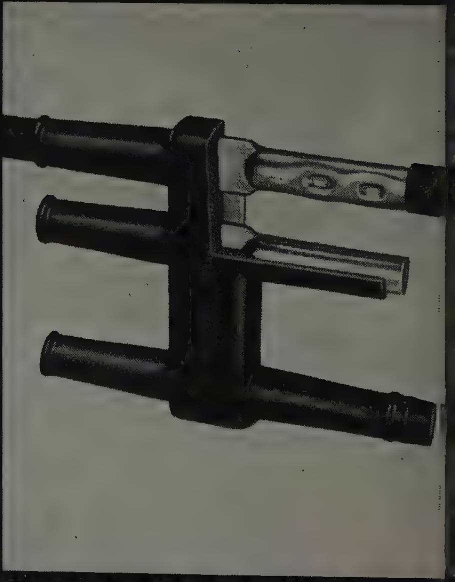
Burndy Hycrabs are multiple connectors providing permanent compression joints. Four to twelve outlets per unit. Completely insulated, Hycrabs are compact and lightweight. Cables quickly, easily installed with Burndy Hypresses.

For coordinated cable protection, a variety of Burndy Limiters is available to isolate and localize cable faults. Limiters may be used with Moles, Hycrabs, or on ring bus

Call your Burndy representative for details or write for Underground Catalog Z47.



Installed Burndy Mole showing socket and nut method of connection. Plugs, like the one shown, protect unused outlets until needed for expansion.



Cutaway picture of Burndy Hycrab. Note heavy mol
rubber insulation and simple indent method of
stallation.

the faulted cable will blow. A similar action occurs in the other end of the faulted cable. Acting in this way, Limiters isolate the faulted cable from the network without disturbing the rest of the network. The source of the trouble can be quickly located, easily repaired. Explosions due to overheated insulation, and spread of damage, are prevented.

Coordination of Limiter and Cable Insulation Damage Curve

Since the basic function of the Limiter is to protect the cable which is faulted, *the Limiter must blow before the insulation reaches the roasting point.* Hence, a properly designed Limiter must coordinate with the insulation damage characteristic of the cable.

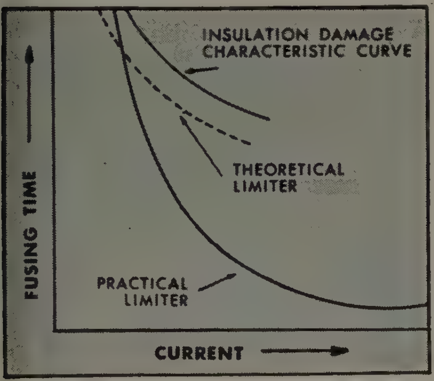


Fig. 2—Typical Insulation Damage Curve

Fig. 2 is a typical insulation damage curve of time plotted against current (seconds vs. amperes) showing the insulation damage characteristic curve for a specific size of cable. In addition, the ideal Limiter curve and the practical Limiter curve are shown. The ultimate Limiter is simple, rugged enough to withstand normal operating conditions during the life of the cable, and practical to manufacture.

Since Limiters are also electrical connectors, they take many forms. In all cases, these Limiters are secured to the cables by means of a mechanical or a compression type connection. No solder is used, because, at the operating temperatures required of Limiters, solder would melt and therefore prevent proper Limiter operation.

Limiters must coordinate with the cable, coordinate with each other, coordinate with Network Protector Fuses. Through engineered design and accurate fabrication, Burndy maintains the integrity and quality of this product, and makes Limiters one of the most valuable assets in the operation of modern AC secondary networks.

All component parts of a Limiter Assembly are shown in Fig. 3.

Fig. 3—Limiter Components

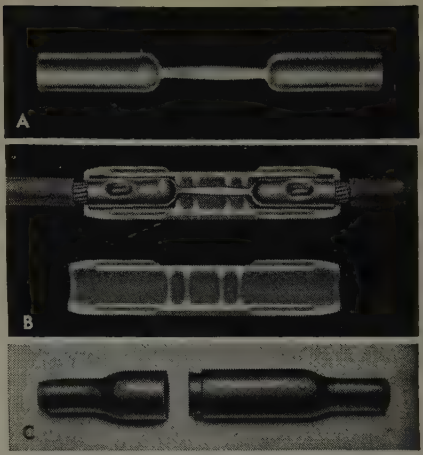


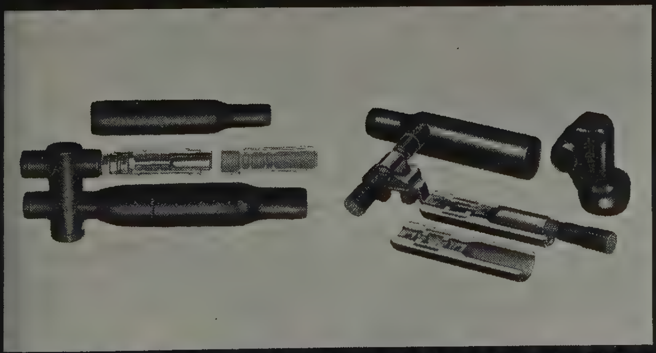
Fig. 3A shows the Limiter itself. This connector has been fabricated from a single length of copper tubing and is hot-tin dipped. It is composed of two sockets joined by a fusible section which has been flattened and is accurately formed to provide proper fusing characteristics. Fig. 3B shows the cables installed at each end by indenting with a Burndy Hypress. The heat resistant shell incorporates barriers which quench the arc rapidly. Fig. 3C shows the insulating sleeve which is used over the entire assembly and sealed by taping.

In particular, note the shape of the fusible section. The reduced section at either end enables the Limiter to have a characteristic curve more nearly approaching the theoretical curve by reducing the heat drain to more massive ends of the Limiter.

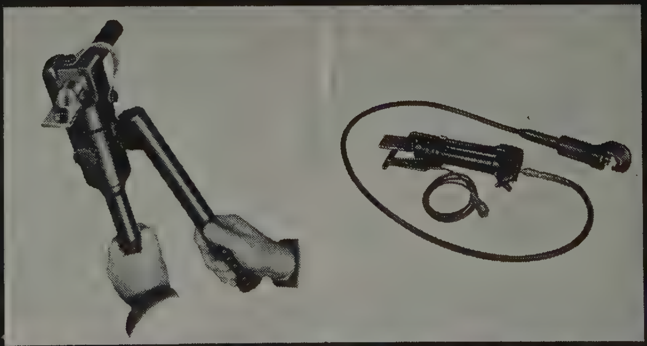
53-21

GROUND

BURNDY MOLE LINE EQUIPMENT



Burndy Limiters. Two variations are shown. At left, Molimiter installed on Mole. At right, exploded view of Limiter Tap before compression—a ring bus connector which also provides overload protection.



Manual Hypress, weighing 9 lbs., delivers 9 ton crimping force. Neoprene covered. Rotating head 90°. Foot operated Hypress handles cable through 2,000 Mcm with pressures to 80,000 lbs. Swivel jointed, flexible, high pressure hose permits use at any angle. Ground lead protects operator.

BURNDY

NORWALK, CONNECT.

FACTORIES: New York, California, Toronto
EXPORT: Philips Export Corporation

TORONTO, CANADA

STABILITY!
ACCURACY!
PRECISION!

Carefully crafted for matchless performance, Silicohm and Dalohm resistors are designed and made to survive the most severe environmental, shock and vibration conditions.

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Miniature Wire Wound
POWER RESISTORS

Complete welded construction from terminal to terminal. Temperature coefficient 0.00002/ deg. C. Ranges from 0.1 Ohm to 55,000 Ohms, depending on Type, Tolerance 0.05%, 0.1%, 0.25%, 0.5%, 1%, 3%, 5%.

RH TYPE — Available in 25, 50 and 250 watt sizes. Silicone sealed in die-cast, black anodized radiator finned housing for maximum heat dissipation.

RS TYPE — Available in 2 watt, 5 watt, and 10 watt sizes. Silicone sealed offering maximum resistance to abrasion, high thermal conductivity and high di-electric strength.

DALOHM
DEPOSITED
CARBON RESISTORS

Dalohm precision deposited carbon resistors offer the best in accuracy, stability, dependable performance and economy. Available in ½ watt, 1 watt and 2 watt sizes.

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for price and delivery.
Phone 2139.

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INDUSTRIAL NOTES ....

Westinghouse News. Russel E. Ebersole, general sales manager of the Westinghouse Lamp Division, has announced the appointment of four new aides to his staff and the promotion of a fifth in an expansion of the division's sales organization. Charles E. Erb of Akron, Ohio, has been named to the newly created post of merchandising manager, and Robert J. Sampson, formerly on the sales staff of the division's central district, has been made manager of sales training. Robert H. Voorhis, former supervisor of market planning, has been appointed manager of that department with expanded responsibilities, and Willard L. Adamus of the division's research section has been named staff assistant to Mr. Voorhis. William F. Tremmel, Jr., will be staff assistant to the manager of the order services and warehouse department.

To attain the closest possible integration of all production facilities at the Westinghouse Lamp Division with headquarters in Bloomfield, N. J., the manufacturing operation has been changed. Appointed to the newly created post of manager of manufacturing is James E. Woodall, formerly a lamp division staff-assistant. The new post of manager of manufacturing engineering is to be filled by William J. Williams, formerly manager of parts plants. Elwood W. Noxon, formerly manager of southern plants, has been appointed manager of northern plants and will be responsible for operations at the Trenton and Bloomfield, N. J., lamp manufacturing plants as well as at the lampbase-making plant at Belleville, N. J. Succeeding Mr. Noxon will be Charles T. Nichols, formerly manager of the Reform, Ala., plant. Mr. Nichols will be responsible for the Little Rock, Ark., Reform, and Richmond, Ky., lamp manufacturing plants as well as the parts plant at Paris, Tex.

F. M. Sloan, general manager of the Lamp Division at Bloomfield has announced the appointment of L. J. Fitzpatrick as his assistant. Mr. Fitzpatrick was assistant to the manager of the Television-Radio Division.

All headquarters offices of the Television-Radio Division have been shifted from the Sunbury, Pa., television-radio plant to the new Metuchen, N. J., plant. The new 450,000-square-foot headquarters plant will employ nearly 3,000 persons.

William H. Eutzy has been appointed assistant to T. J. Newcomb, manager of the Television-Radio Division, to succeed Mr. Fitzpatrick. Mr. Eutzy formerly was supervisor of the division's industrial relations department.

General Electric Notes. Plans for a new metallurgical development laboratory as part of the company's Research Laboratory at the Knolls, near Schenectady, N. Y., have been announced. The new facility will provide more than 70,000 square feet of floor space, raising the gross area of the laboratory to more than half a million square feet, and will be the eighth building of those comprising the Research Laboratory. The building is scheduled for completion by the spring of 1955.

G. A. Bradford has been named manager of advertising and sales promotion for the radio and television department with offices at Electronics Park, Syracuse, N. Y. Prior to his present appointment, Mr. Bradford was advertising manager of the tube department in Schenectady.

Douglas J. Sullivan has been named to the newly created position of manager of personnel development for the marketing section of the tube department. Before his new appointment, he was manager of employee and plant community relations for the department.

R. M. Lutz, formerly associated with the sales staff of the radio and television department at Syracuse as a sales assistant, has been designated District Manager of the Philadelphia (Pa.) District for the department. He will be responsible for the sale of radio and television receivers to the General Electric Supply Companies of Philadelphia and Allentown, Pa.; Raub Supply Company, Lancaster, Pa.; and Lowry Electric Company, Williamsport, Pa.

James P. Dempsey has been made manager of employee and plant community relations for the welding department in York, Pa. The welding department, now located in Fitchburg, Mass., will transfer to York in a move that is expected to be completed by March 1954. Manager of sales for the welding department will be Edward K. How, formerly sales manager for the Locke Department.

Wisconsin Power Staff Changes. Carl J. Forsberg of Madison, Wis., has been elected vice-president in charge of operations of the Wisconsin Power and Light Company. In his new assignment, he will direct the company's 14 operating districts, all of the major generating plants, the operations and maintenance department, the sales department, and all automotive equipment. Mr. Forsberg joined the company in 1934 as industrial engineer. Most recently he was vice-president in charge of field operations.

Milton H. Frank, executive vice-president, retired from active service recently after 41 years in the utility business. He will remain a member of the Board of Directors. Mr. Frank entered the utility field in 1912 following his graduation from Purdue University. In 1918 he joined the Eastern Wisconsin Electric Company, and this company later became a part of Wisconsin Power and Light.

Oak Ridge Appointment. W. W. Grigorieff, director of the Institute of Science and Technology of the University of Arkansas, has been named chairman of the University Relations Division of the Oak Ridge (Tenn.) Institute of Nuclear Studies. Dr. Grigorieff succeeds Russell S. Poor who has become provost of the

(*Continued on page 26A*)

NEW!

high-current, heavy-duty capacitors for r-f noise suppression

50 ampere
Vitamin Q® Impregnated
THRU-PASS®
CAPACITORS

Now you can get a really effective r-f noise suppression capacitor for use in high-current, heavy-duty applications.

Originally developed for 115/250 volt a-c lines in mobile military power units, these new Sprague Type 112P Thru-Pass capacitors have now been released for general use.

The entire shell of these capacitors is threaded except for two straddle milled flats. When mounted in a flatted circular hole in a chassis or bulkhead wall, they will not rotate and loosen under vibration. There is always a noise-leakproof closed path encircling the feed-thru conductor so that the theoretical effectiveness of these capacitors is realized in actual practice.

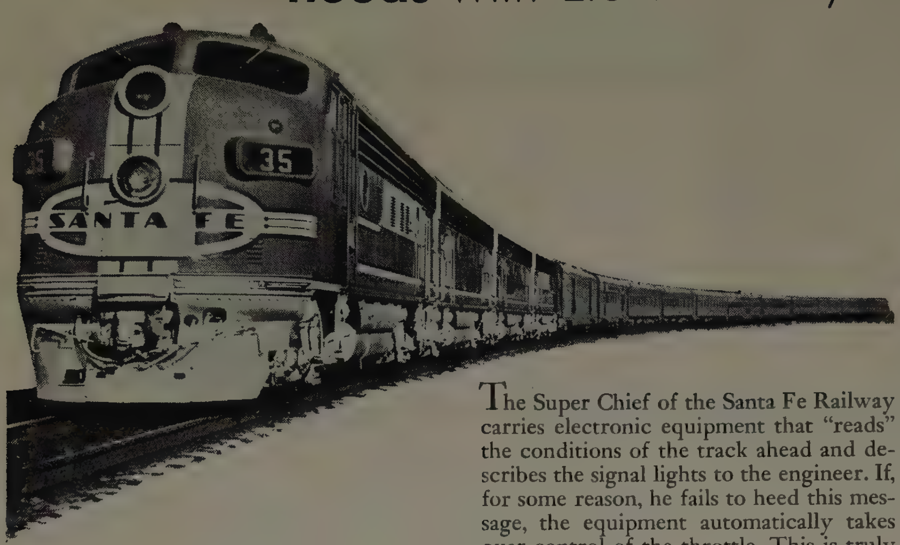
The typical insertion loss curves for sub-miniature Thru-Pass units shown in Bulletin 215 are also representative of these larger capacitors. Other characteristics are fully described in Engineering Bulletin No. 216. Write to Sprague Electric Company, 321 Marshall Street, North Adams, Massachusetts.

Sprague, on request, will provide you with complete application engineering service for optimum results in the use of radio noise suppression capacitors.

SPRAGUE
WORLD'S LARGEST CAPACITOR MANUFACTURER

EXPORT FOR THE AMERICAS: SPRAGUE ELECTRIC INTERNATIONAL LTD., NORTH ADAMS, MASS. CABLE: SPREXINT

The Iron Horse that **reads** and **heeds** with Electronic Eyes



The Super Chief of the Santa Fe Railway carries electronic equipment that "reads" the conditions of the track ahead and describes the signal lights to the engineer. If, for some reason, he fails to heed this message, the equipment automatically takes over control of the throttle. This is truly *safety in motion*.

Holtzer-Cabot motor generator sets, which power electronic equipment on the Super Chief control system, employ Regohm voltage regulators exclusively. Wherever the going gets rough on land, sea or air applications, this compact, electro-mechanical controller withstands severe vibration, shock or ambient temperature conditions. And standard models provide voltage output constant within less than ±2%.

Here are the reasons why Holtzer-Cabot engineers have standardized on Regohm voltage regulators:

1. Low Cost—Regohm costs less, does more, than the complex equipment that once was the only available solution to control problems.

2. Ruggedness—Upgrade, downgrade, working on a railroad demands the ability to "take it." Regohm has it, is both sturdy and reliable.

3. Long Life—In properly engineered installations, Regohm's life is measured in years. This means low maintenance cost. Shelf-life is substantially unlimited.

4. Simplified Maintenance—Regohm's plug-in feature simplifies replacement and maintenance by unskilled crews. There are no parts to renew or lubricate.

5. Good Regulation—Regohm insures continuous control and will stabilize control systems that have widely varying characteristics.

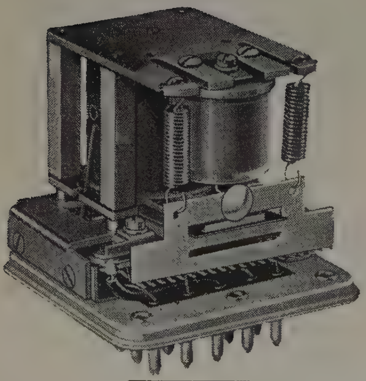
Our engineering and research staff can help you develop optimum design for your equipment and system. Learn how the Regohm can help you with your regulation problem. Write for Bulletin 505.00. Address: Department EN, Electric Regulator Corp., Norwalk, Conn.

Powered

by Holtzer-Cabot Generators

Controlled

by Regohm Voltage Regulators



REGOHM

CONTROL COMPONENT IN: Servo systems • battery chargers • airborne controls • portable and stationary generators • marine radar • inverters • locomotive braking systems • mobile telephones • guided missiles • signal and alarm systems • telephone central station equipment • magnetic clutches • railroad communication systems.

(*Continued from page 24A*)

University of Florida Health Center. The University Relations Division administers a number of fellowship programs for the Atomic Energy Commission and with Oak Ridge National Laboratory carries out research participation, Oak Ridge graduate, and other programs of interest to universities.

Honeywell Names Eastern Sales Head. The appointment of Fred Kaiser as manager of the Eastern region of Minneapolis-Honeywell Regulator Company, with headquarters in New York, N. Y., was announced recently. The Eastern region, largest in the company's sales network, covers New York, New Jersey, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine.

Arnold Michelson, who has been handling the regional manager's duties, has been given additional duties and responsibilities as resident vice-president. He will continue to make his headquarters in New York.

Kilbon Joins RCA. Kenyon Kilbon, former staff member of the New York *Herald Tribune*, has joined the staff of the Department of Information of the Radio Corporation of America, New York, N. Y. Since 1950 Mr. Kilbon had been with the Economic Co-operation Administration as Marshall Plan information officer in the Netherlands, returning to the United States last December on assignment as a European area specialist with the International Information Administration in Washington, D. C.

New Hammarlund Sales Office. The Hammarlund Manufacturing Company, Inc., New York, N. Y., has announced the opening of an office in Chicago, Ill., to handle Midwest sales and servicing. The new office will be responsible for sales in Wisconsin, Minnesota, Illinois, Kentucky, Michigan, Indiana, and Ohio. Ray Ramon, formerly district sales manager for the Fred L. Tourtelot Company, has been appointed Midwest sales manager.

S & C Announcements. The S & C Electric Company, Chicago, Ill., has announced the formation of a Canadian associate, S & C Electric Canada, Ltd., in Toronto, Ontario, Canada. John R. Conrad, president of S & C, is president of the new Canadian affiliate. John B. Hallamore, vice-president, is in charge of over-all operations, and Alex R. Morrison is general sales manager. Both Mr. Hallamore and Mr. Morrison were associated with the Canadian licensee of S & C.

William A. Gussow has joined the S & C engineering department in Chicago as a design engineer. Mr. Gussow has had almost 25 years of engineering experience with the Cole Electric Company, Culver City, Calif., and the Southern States Equipment Corporation, Hampton, Ga.

(*Continued on page 30A*)

What do YOU make that takes wire?

If you make sieves or staples, screws or screens—whatever you make that takes wire—we're pretty sure to have the kind of manufacturers wire you need. Round, flat, square . . . hard, soft, ductile . . . plain, tinned, or bright finished . . . carbon, alloy, or stainless. Altogether we produce over 400 different types of wire which are suitable for practically all everyday wire applications.

But, if you need a special kind of wire, we can supply that too. Our modern plant facilities enable us to draw wire to meet the exact specifications of a special order, and our trained metallurgists are always ready to assist you with any manufacturing problems you may have.

We've been in the wire-making business more than one hundred years, and all of our experience is at *your* service . . . to help you do an easier and better fabrication job.

If you make it of wire...
make it of the best!

U·S·S AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

STABILITY *in flight*

RECORDED ACCURATELY By Century Model 409 RECORDING OSCILLOGRAPH

The Century Model 409 Oscillograph was designed for operation under the most adverse conditions, especially where space and weight considerations are limited. It is a miniature, compact unit incorporating many features found in larger models. Records faithfully during accelerations and shock in excess of 20 G's. Its size and capacity make it especially desirable for use in missile launching, parachute seat ejection, flight test of helicopter and fighter aircraft and torpedo studies.

Century GEOPHYSICAL CORPORATION
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Long Island City, N. Y.

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Philadelphia 40, Pa.

3406 W. Washington Blvd.
Los Angeles 18, Calif.

238 Lafayette St.
Dayton 2, Ohio

504 Interurban Bldg.
Dallas, Texas

EXPORT OFFICE
149 Broadway, N. Y. City

(*Continued from page 26A*)

Smith to Represent BullDog. BullDog Electric Products Company, Detroit, Mich., has announced the appointment of Milton C. Smith as the company's merchandising representative in Buffalo, N. Y. Mr. Smith represented the R. J. Reynolds Company in Newark, N. J., and MacGregor Sportswear of Dover, N. J., before joining BullDog Electric.

Radiomarine Personnel Changes. Changes in the Radiomarine Corporation of America's field sales and service organization have been announced. G. I. Martin has been transferred from St. Louis, Mo., to Houston, Tex., where he will assume the duties of assistant regional sales manager of an enlarged sales region. G. A. Freeman was transferred from Houston to New Orleans, La., as manager of sales and service. R. W. Ugel, former service manager at St. Louis, has been appointed manager of sales and service of that office. B. H. Baskin will assume the duties of chief service technician at both the Houston and Galveston, Tex., offices.

AC&R Elects Baker. Hugh Benton Baker, senior partner of Baker, Weeks and Company, has been elected a member of the Board of Directors of American Cable and Radio Corporation, an associate of International Telephone and Telegraph Corporation. Mr. Baker fills the vacancy created by the death of George Weeks, his former partner, and for many years a director of American Cable and Radio Corporation.

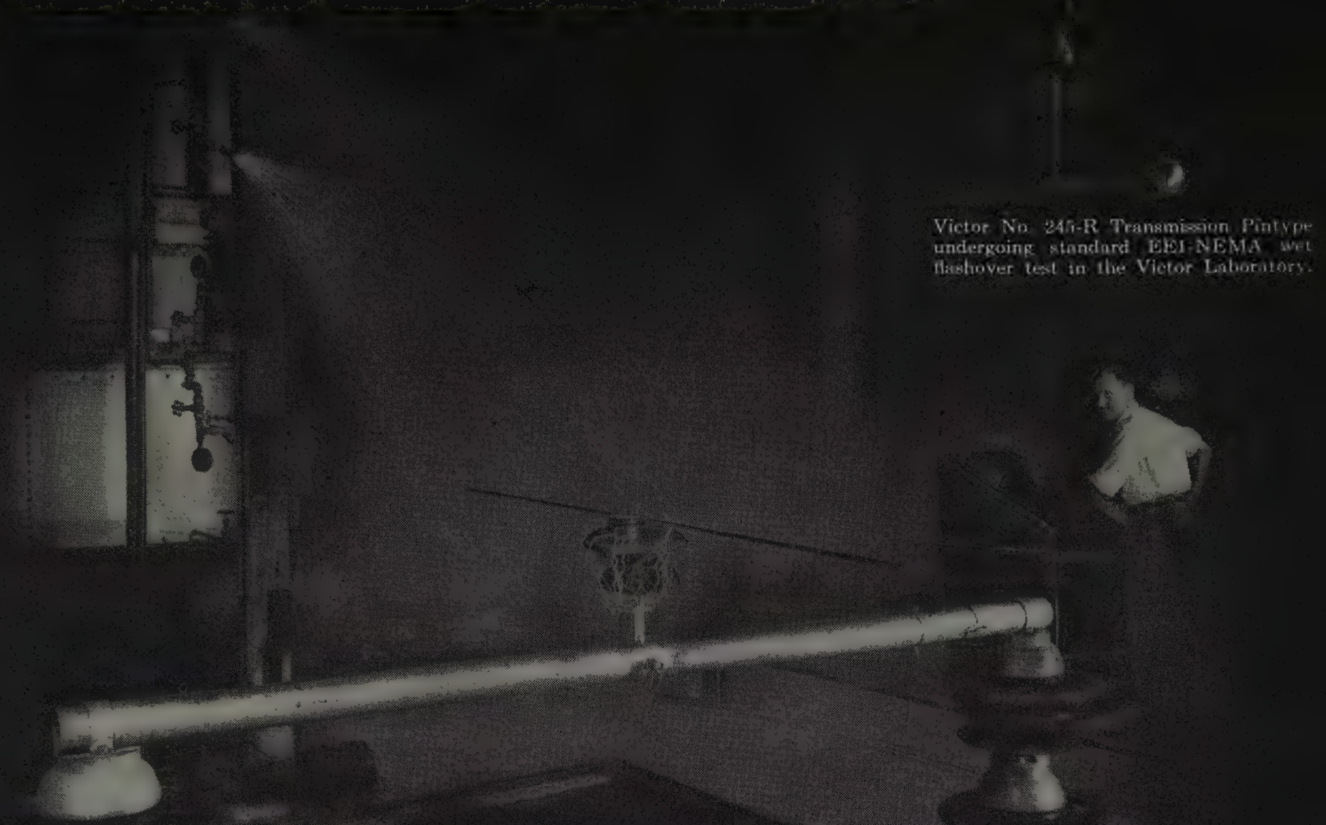
New Motorola Plants. Two plants now under construction on North Cicero Avenue in Chicago, Ill., will be occupied by manufacturing and parts and service departments of Motorola, Inc. The acquisition of the modern twin 1-story plants, which cover an area of 150,000 square feet, is part of an over-all expansion and realignment program.

Electronic Control Firm Organized. Stromberg-Carlson Company announces its participation in the establishment of a new industrial process control firm known as Electronic Control Systems, Inc., in Los Angeles, Calif. The new firm, headed by Leonard Mautner as president and Alexander F. Brewer as executive vice-president and secretary, will concentrate its efforts in seeking out and solving selected problems in the fields of automatic process control and data handling. R. C. Tait, president of Stromberg-Carlson, is serving as a director of the newly organized company.

Drew Joins Line Material. J. N. Drew has been appointed field engineer in the Line Material Company's South Central Division to handle sales in western Tennessee, northern Mississippi, and southeastern

(*Continued on page 42A*)

WE MAKE OUR OWN RAIN . . .



Victor No. 245-R Transmission Pintype undergoing standard EEI-NEMA wet flashover test in the Victor Laboratory.

TO GIVE YOU

PROVEN WET WEATHER PROTECTION

The superiority of Victor design and manufacture is proven in the laboratory as well as in the field. Take Victor High Voltage Pintypes, for example. Here, in the wet flashover test shown above, the insulator is being subjected to controlled artificial rain while 60-cycle current is applied in gradually increased voltage steps until flashover occurs.

This is only one of the many tests which are constantly being made in the Victor Testing Laboratories to assure you of highest quality and conformance to specifications. That is why Victor Transmission Pintypes give you proven wet weather protection and longer, trouble-free service on your lines. Choose Victor—the power man's best buy!

VICTOR No. 245-R
EEI-NEMA Class 56-3

FREE BOOKLET gives you the full story of how Victor Insulators are made how and why Purified Porcelain was developed. Write us for your copy.

Specify
VICTOR INSULATORS!

VICTOR INSULATORS, INC., VICTOR, N. Y.

Low and High Voltage Pintypes • Suspensions • Guy Strains • Spools • Switch and Bus Insulators • Custom Designed Porcelain

STACKPOLE

CARBON and GRAPHITE SPECIALTIES

Get this helpful booklet! In addition to details on Stackpole products, this 44-page Booklet 40A includes helpful engineering discussions on the physical and electrical properties of carbon and graphite. Copy sent free on letterhead request.

- GRAPHITE TUBE ANODES
- BATTERY CARBONS
- GROUND RODS
- NON-WELDING ELECTRICAL CONTACTS
- VOLTAGE REGULATOR DISCS (carbon piles)
- WATER HEATER and PASTEURIZATION ELECTRODES
- BEARINGS
- WELDING RODS
- WELDING PLATES and PASTE
- RESISTANCE WELDING and BRAZING TIPS
- CHEMICAL CARBON and GRAPHITE (Plain or Treated)
- CARBON RODS FOR SALT BATH RECTIFICATION
- TROLLEY SHOES
- SEAL RINGS
- FRICTION SEGMENTS
- CLUTCH RINGS
- BRAZING FURNACE BOATS
- ELECTRIC FURNACE HEATING ELEMENTS
- MOLDS and DIES
- CONTINUOUS CASTING DIES

STACKPOLE CARBON COMPANY
St. Marys, Pa.

EVERYTHING IN CARBON BUT DIAMONDS

(*Continued from page 30A*)

Kentucky. His headquarters will be in Memphis, Tenn. Mr. Drew previously was plant electrical engineer for the Crossett Paper Mills at Crossett, Ark.

Brush Appoints Novak and Arndt. As another step in the reorganization of the Brush Electronics Company's Sales Division, J. P. Arndt, Jr., former manager of the crystal sales department, has been appointed assistant general sales manager in charge of staff functions such as sales promotion, advertising, customer service, distribution control, sales training, market research, and order service. Mr. Arndt succeeds A. J. W. Novak, assistant general sales manager for operations, now in a new post as head of all lines sales activities including the equipment, tape recorder, component, and international departments.

Scientists Join North American. Two scientists in the field of nuclear energy have joined the staff of North American Aviation, Inc., atomic energy research department. Dr. John P. Howe has been appointed chief of the reactor materials section, and Dr. Robert L. Loftness has been made group leader of chemical development under Dr. Howe. Dr. Howe previously was with the General Electric Company, where he organized and managed the metallurgy section of the Knolls Atomic Power Laboratory. Dr. Loftness recently returned from Stockholm, Sweden, where he served since 1951 as a scientific attache at the American Embassy.

Union Switch Personnel Changes. William R. Gracey, Jr., formerly assistant section head, simulator engineering, has been appointed section engineer, training aids, at Union Switch and Signal, Swissvale, Pa., a division of the Westinghouse Air Brake Company. He has been with the company since 1944. Paul K. Eckhardt has been made section engineer, traffic control. Mr. Eckhardt, who joined Union Switch and Signal in 1931, had been a supervisor, centralized traffic control. Kenneth J. J. McGowan has been appointed section engineer, mechanical products. Joining the company in 1939, he was most recently project engineer, mechanical.

Walter Kidde Appointments. Newly appointed as department heads at the Walter Kidde Nuclear Laboratories, Garden City, N. Y., are Cecil B. Ellis, research department, Laboratory Division; J. J. Byrnes, engineering department, Laboratory Division; and Karl Puechl, theoretical department, Development Division. Dr. Ellis formerly was co-ordinator of the Nuclear Aircraft Project at the Oak Ridge National Laboratory, Mr. Byrnes has been identified with the atomic energy field since 1943 when he was employed at Columbia University on the gaseous diffusion pilot plant, and Mr. Puechl has

(*Continued on page 50A*)

Iron, Sister!!...

THIS **NEW**

Wire-Wrap Tool

MAKES SOLDERLESS CONNECTIONS

...in half the time!

Manufactured under patent
license agreement with
Western Electric Company
Incorporated

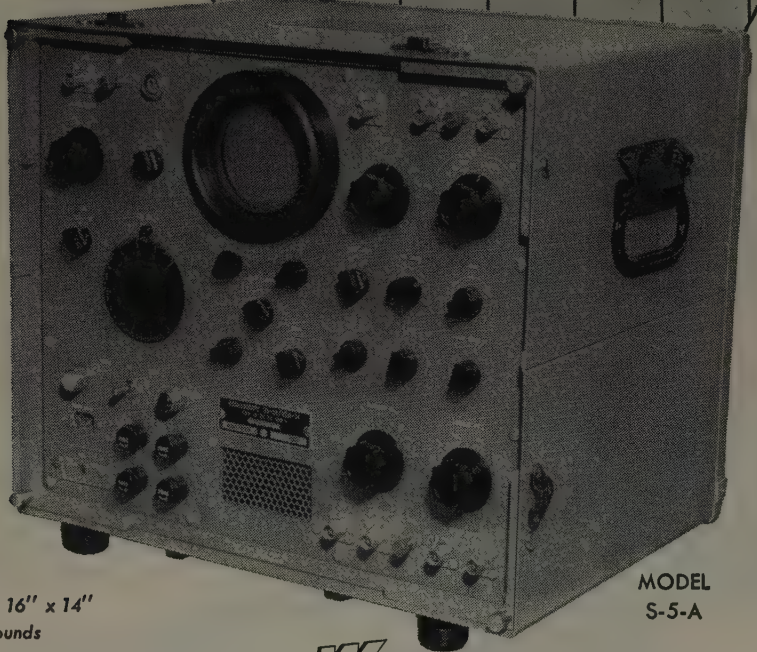
3 *IT'S FASTENED*

AIR TOOL WEIGHS
ONLY ONE POUND

KELLER
Wire-Wrap
TOOLS
Wire-Wrap Division

KELLER TOOL CO.
Grand Haven, Michigan

the Waterman
LAB
PULSESCOPE®



Size:
13" x 16" x 14"
60 Pounds

MODEL
S-5-A

ANOTHER EXAMPLE OF Waterman PIONEERING...

The LAB PULSESCOPE, model S-5-A, is a compact, wide band laboratory oscilloscope for the study of all attributes of complex waveforms. The video amplifier response is up to 11 MC and provides an equivalent pulse rise time of 0.035 microseconds. Its 0.1 volt p to p/inch sensitivity and 0.55 microsecond fixed delay assure portrayal of the leading edge when the sweep is triggered by the displayed signal. An adjustable precision calibration voltage is incorporated. The sweep may be operated in either triggered or repetitive modes from 1.2 to 12,000 microseconds. Optional sweep expansion of 10 to 1 and built-in markers of 0.2, 1, 10, 100, and 500 microseconds, which are automatically synchronized with the sweep, extend time interpretations to a new dimension. Either polarity of the internally generated trigger voltage is available for synchronizing any associated test apparatus. Operation from 50 to 1000 c.p.s. at 115 volts widens the field application of the unit. These and countless additional features of the LAB PULSESCOPE make it a MUST for every electronic laboratory.

WATERMAN PRODUCTS CO., INC.
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CABLE ADDRESS: POKETSCOPE

MEMO... Write for details today!

WATERMAN PRODUCTS INCLUDE
S-4-A SAR PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE®
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S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE

Also RAYONIC® Cathode Ray Tubes and Other Associated Equipment

WATERMAN PRODUCTS

(*Continued from page 42A*)

been a member of the Walter Kidde Laboratories since the establishment of the company. Staff additions to the Laboratory Division include: G. Bartolomei, Sr., project engineer, formerly with Specialties, Inc.; D. M. Benforado, junior chemical engineer, formerly with Shell Oil Company; and C. W. Stanley, scientist, formerly with Los Alamos Scientific Laboratories. Staff additions to the Development Division include: B. J. Byrne, junior engineer, graduate of New York University; S. Millman, junior scientist, formerly with Watertown Arsenal; H. Yanowitz, junior engineer, formerly with the National Advisory Committee for Aeronautics; and M. Zizza, junior engineer, formerly with Stauffer Chemical Company.

NSF Assignment to Ewell. Dr. Raymond H. Ewell, manager of the Chemical Economics Service for the Stanford Research Institute, Stanford, Calif., has been granted an extended leave of absence to become Assistant Director for Program Analysis in the National Science Foundation, Washington, D. C. He will have charge of a program of studies on research relating to the development of a national science policy. The National Science Foundation is an independent government agency instituted by the Congress in 1951.

NEW PRODUCTS • •

RCA Tubes. The following tube types have been announced by the Tube Department, Radio Corporation of America, Harrison, N. J.

The *12AQ5* is a beam power amplifier of the 7-pin miniature type intended primarily for use in the output amplifier of automobile radio receivers operating from a 12-volt storage battery. The application of directed electron beam principles in the design of the *12AQ5* makes it capable of producing relatively high-power output with high-power sensitivity. A single *12AQ5* operated with a plate and screen voltage of 250 volts can deliver a maximum signal power output of 4.5 watts with a peak driving voltage of only about 12 volts.

RCA-207E1 is a new assembled and aligned 40-megacycle intermediate-frequency amplifier complete with tubes and designed for use in television receivers utilizing intercarrier-sound systems having picture intermediate frequency and sound intermediate frequency of 45.75 megacycles and 41.25 megacycles, respectively. The *207E1* features high gain, full 4-megacycle bandpass response, and excellent skirt selectivity. It provides an overall sensitivity of approximately 40 microvolts at 44 megacycles and accurate control of the response-curve shape.

The *5719* is a premium high-mu triode of the subminiature type for use primarily

(*Continued on page 58A*)

ow SUNRAY OIL
osts
pe line capacity
5%

e years ago production skyrocketed
e Sunray Oil Corporation refineries
uncan and Allen, Okla. Expansion
ghout the system overloaded the
h pipe line between the two cities.
er pipe was not available.

nray engineers hit on a cost-cutting
tion—installed three electrically
ered booster stations between regu-
umping stations. They know that
ric motors cost less to install . . .
re little maintenance . . . are easily
ted to remote control circuits.

en engineers selected an RCA 960-
Microwave radio-relay system to
complete remote control of the
ters" from regular pumping sta-
. Microwave stations spaced miles
proved cheaper to install and main-
than direct wire. And Microwave
ms are virtually weatherproof.

hen the Sunray microwave-operated
ters" were put in operation on
ary 31, 1952, *the pipe line's capacity
diately increased 25 per cent!*

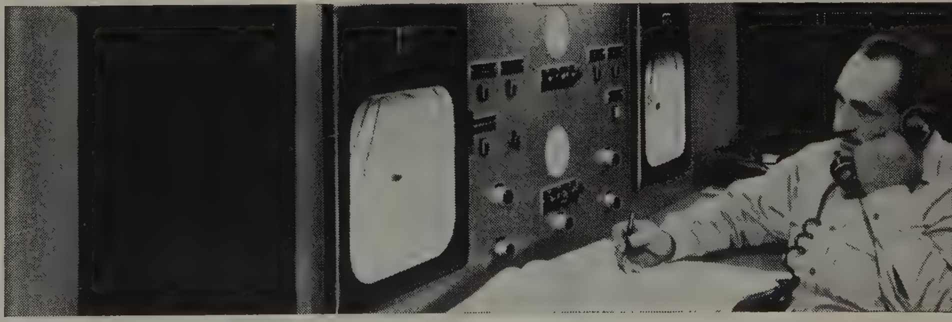
CA Microwave "beams" highly di-
onal radio signals from station to
on by "dish" antennas. Since 1946
has installed many fully reliable
owave systems, some over 1,000
long. *All have proved themselves in
rmance*—for utilities, government
cies, telegraph companies, turn-
, as well as pipe lines.

addition to remote control and
rvisory functions, RCA Microwave
des as many voice and teletype
nels as you need—and does it
a minimum of frequency space. It
oys readily available tubes and
iar circuits which are easy to serv-
t interconnects with your telephone
and switchboards.

ou desire, RCA supervises survey,
ruction and installation—offers a
lete single-source, single-respon-
ty service. And only RCA can pro-
he nationwide service facilities of
CA Service Company.

RCA MICROWAVE
radio-relay communication and remote control

Unattended booster station at Pernell, Okla. Radio-beam signals via RCA Microwave operate the booster by full remote control. Maintenance man inspects each station once every 24 hours.



Telemeter charts give continuous record of power and pressures at boosters. Operator remote-controls valves and pumps of booster stations. Signal lights indicate equipment failure and emergency generator operation. 2-way voice channel contacts maintenance personnel.

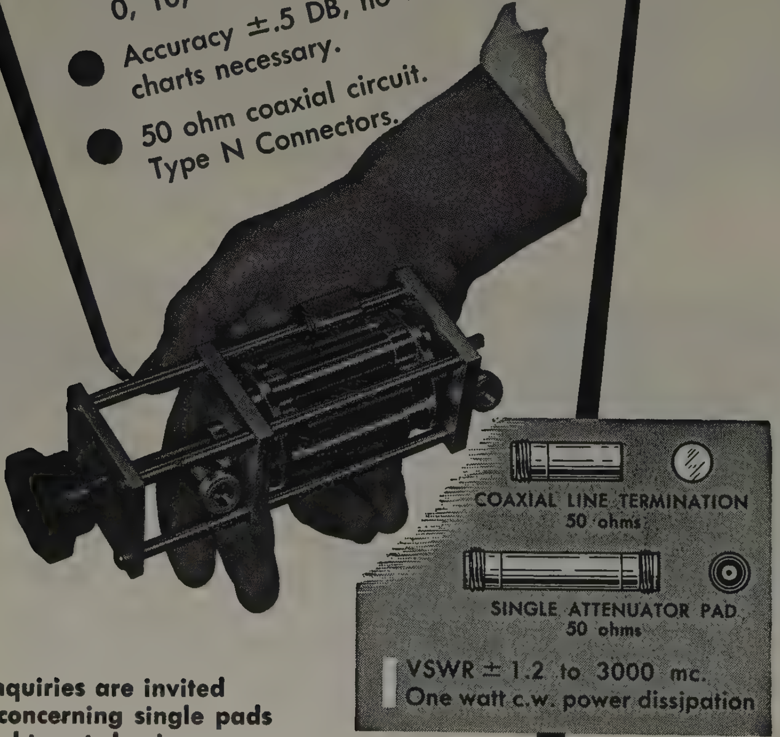
RADIO CORPORATION of AMERICA
COMMUNICATIONS EQUIPMENT CAMDEN, N.J.

Dept.42W, Building 15-1
Without obligation on my part, please send me your free booklet on:
☐ A Booster Station Microwave System ☐ Pushbutton Operation of Boosters

Name__________ Title__________ Company__________
Address__________ City__________ Zone_____ State__________

Precision
ATTENUATION
to 3000 mc!

- VSWR less than 1.2 at all frequencies to **3000 mc.**
- **TURRET ATTENUATOR** featuring **"Pull - Turn - Push"** action with 0, 10, 20, 30, 40, 50 DB steps.
- Accuracy ±.5 DB, no correction charts necessary.
- 50 ohm coaxial circuit. Type N Connectors.



Inquiries are invited concerning single pads and turrets having other characteristics

STODDART AIRCRAFT RADIO CO., INC.
6644-B SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA
HOllywood 4-9294

(*Continued from page 50A*)

as an audio amplifier in mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. In audio service as a resistance-coupled amplifier, the *5719* is capable of providing high-voltage gain. Featured in the *5719* is a compact structure designed to resist shock and vibration and to reduce microphonic output. A pure tungsten heater is used to give long life under conditions of frequent on-off switching.

RCA-5690 is a "special red" vacuum rectifier tube especially designed for industrial and aircraft applications where rigid requirements for dependability, stability, and long tube life are of prime importance. The *5690* has two separate diode units of the indirectly heated cathode type. It is conservatively rated to withstand a maximum peak inverse plate voltage of 1,120 volts, a maximum peak plate current per plate of 375 milliamperes, and a maximum d-c output current per plate of 75 milliamperes.

The *5ABP1*, *5ABP7*, and *5ABP11* constitute a new RCA series of 5-inch flat-face cathode-ray tubes utilizing electrostatic focus, electrostatic deflection, and postdeflection acceleration. They differ one from the other only in the spectral-energy emission and persistence characteristics of their respective phosphors P1, P7, and P11. Outstanding among the features of the *5AB* types are the exceptionally high sensitivity and low capacitance of the pair of deflecting electrodes provided for vertical deflection.

The *5814* is a premium medium-mu twin triode of the 9-pin miniature type for use in many diversified applications including mixers, oscillators, multivibrators, synchronizing amplifiers, and numerous industrial control devices where dependable performance under shock and vibration is a major consideration. Utilized in *5814* is a compact structure designed to resist shock and vibration, a pure tungsten heater to give long life under conditions of frequent on-off switching, a mid-tapped heater to permit operation from either a 6.3-volt or a 12.6-volt supply, and separate terminals for each cathode to provide flexibility of circuit arrangement.

The *5840* is a premium sharp-cutoff pentode of the subminiature type for use primarily as a broad-band radio-frequency or intermediate-frequency amplifier in mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. Featured in the *5840* is a compact structure especially designed to resist shock and vibration, a pure tungsten heater to give long life under conditions of frequent on-off switching, and three leads to the cathode to permit isolation of the input and output circuit returns and to reduce the cathode lead inductance.

Resin for Foamed Structures. Dow Corning *XR-543* resin is a clear, 100-per-cent solid silicone resin. Supplied as

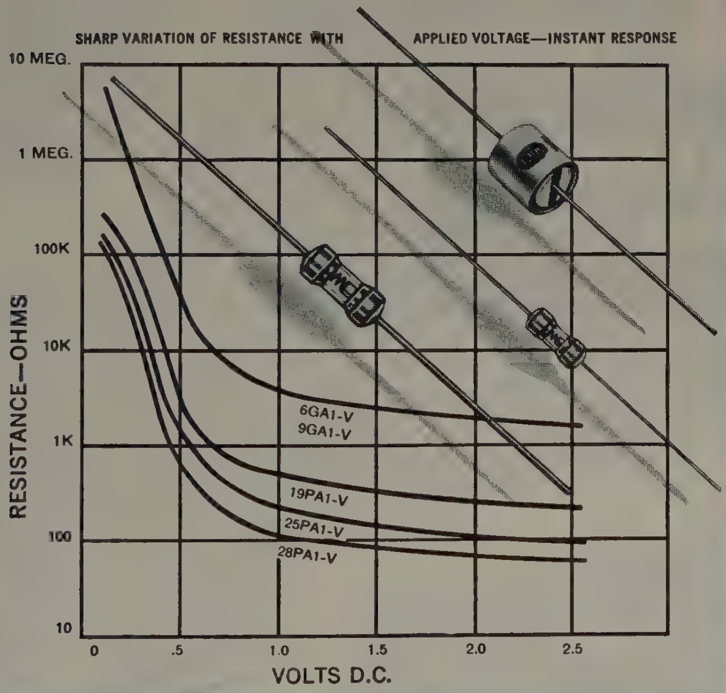
(*Continued on page 60A*)

NOW

an IRC VARISTOR | *non-linear resistor*

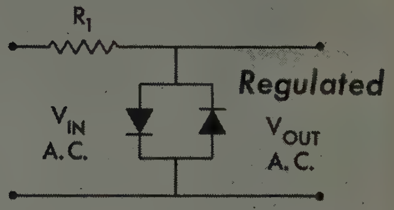
New IRC VARISTORS are voltage sensitive, non-linear resistors. They provide a sharp variation of resistance with applied voltage. They are supplied in 5 convenient cell sizes with a complete choice of enclosures, including hermetic seals.

Minimum voltage is less than .25V, and continuous currents may range up to 110 ma. IRC VARISTORS are stable, have low shunt capacitance, and can be furnished within close tolerances.

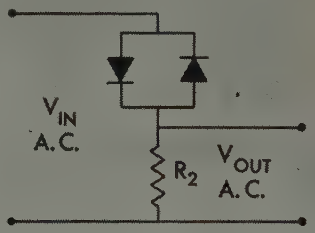


TYPICAL APPLICATIONS

VOLTAGE REGULATION OR SIGNAL CLIPPING.



LOGARITHMIC CONVERTER. Large changes in output voltages are obtainable with small changes in input voltages.



TYPICAL COSTS

Type 25PA1-V, in lots of 500: 25c each. Type 9GA1-V (hermetically sealed in glass) in lots of 500: 45c each.

SEND COUPON FOR 6 PAGE DATA BULLETIN SHOWING ADDITIONAL APPLICATIONS, PLUS CHARACTERISTICS AND SPECIFICATIONS.

Boron & Deposited Carbon Precistors • Power Resistors • Voltmeter Multipliers • Low Wattage Wire Wounds • Insulated Composition Resistors • Volume Controls •

[illegible]

Precision Wire Wounds • Ultra HF and Hi-Voltage Resistors • Low Value Capacitors • Selenium Rectifiers • Insulated Chokes • Hermetic Sealing Terminals •

IRC

INTERNATIONAL RESISTANCE CO.
411 N. Broad Street, Philadelphia 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

Send Bulletin describing IRC Varistors:

*Name*____________________

*Title*____________________

*Company*____________________

*Address*____________________

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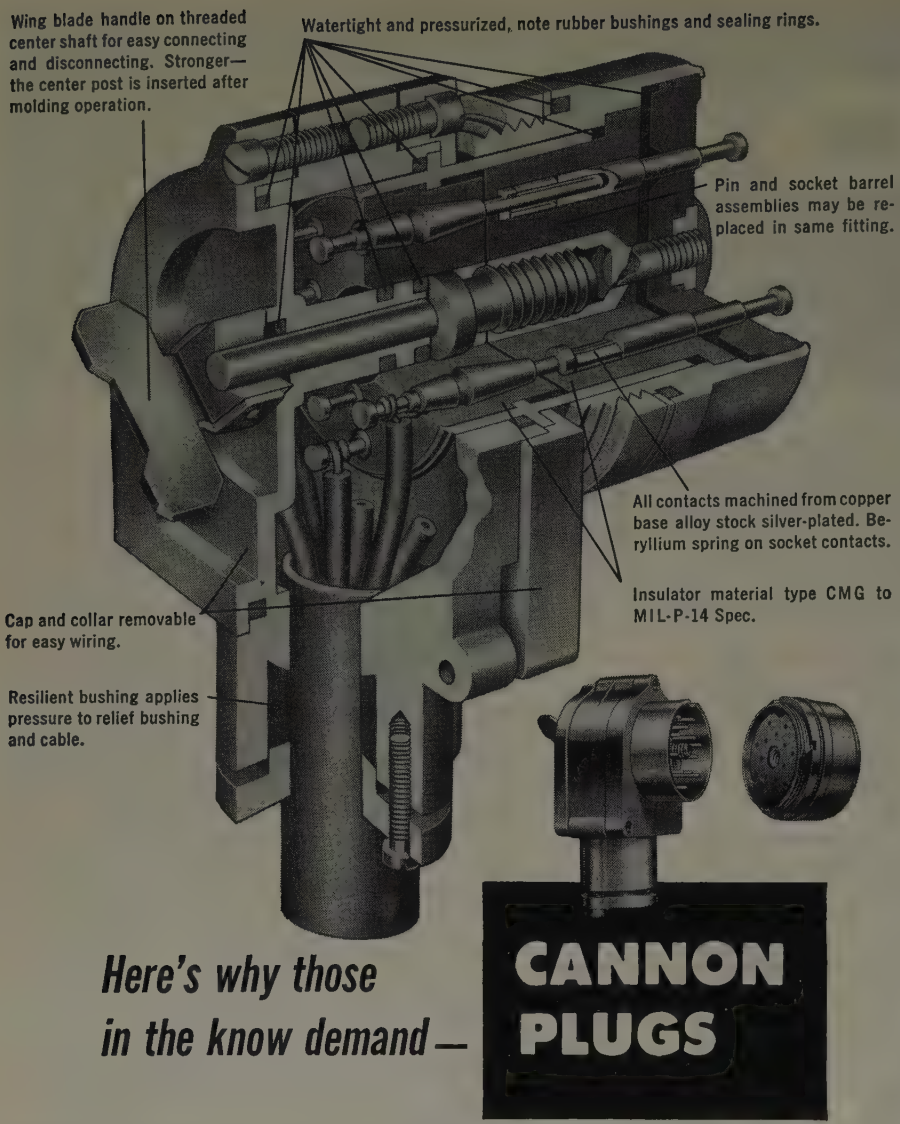


Wing blade handle on threaded center shaft for easy connecting and disconnecting. Stronger—the center post is inserted after molding operation.
Watertight and pressurized, note rubber bushings and sealing rings.
Pin and socket barrel assemblies may be replaced in same fitting.
All contacts machined from copper base alloy stock silver-plated. Beryllium spring on socket contacts.
Insulator material type CMG to MIL-P-14 Spec.
Cap and collar removable for easy wiring.
Resilient bushing applies pressure to relief bushing and cable.
CANNON PLUGS

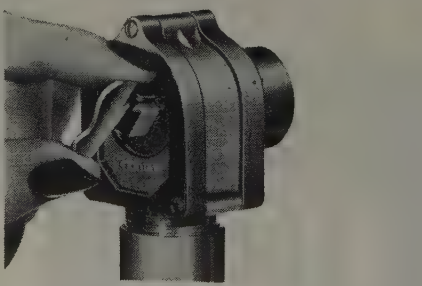
Here's why those in the know demand—

TYPE 2E Sealed Power Connector (Signal Corps numbers U-112/U to U-118/U) is typical of Cannon's foresighted engineering to do a better job. The 2E Series is designed for heavy duty service on Signal Corps power units for audio equipment.

Features:

a. Longer contact engaging length.
b. Thicker inserts of greater tensile strength to reduce breakage.
c. Closed entry socket contacts.
d. Special sealing rings which do not require sealing compound or gaskets.
e. Efficient neoprene clamp gland.

Manufactured in accordance with Specification MIL-C-1252 (Sig. C) the 2E Series Plug has cable clamping provision from 0.205 to 0.770 inclusive. Quick connect and disconnect are accomplished by a wing handle and threaded center screw that can be operated by gloved hands in extreme climatic conditions. Two shell sizes accommodate four insert arrangements of 4, 9, and 19 contacts. Watertight and pressurized, with rugged construction, Cannon's 2E Sealed Power Connectors are built for long life and trouble-free service and are adaptable to industrial application. Write for Advance Bulletin No. 2E-1.



CANNON ELECTRIC
Since 1915
CANNON ELECTRIC COMPANY, LOS ANGELES 31, CALIFORNIA
Factories in Los Angeles; New Haven; Toronto, Canada; London, England. Representatives in principal cities. Address inquiries to Cannon Electric Company Dept. K-117, Los Angeles 31, California.

(*Continued from page 58A*)

a brittle solid, it readily melts on heating to 280 to 300 degrees Fahrenheit. Melted, it can be stirred easily with a mechanical mixer while adding the blowing agent and catalyst. The hot molten mixture then can be transferred to the desired size container and heated for the required time at 300 degrees Fahrenheit to produce a foam density of 14 to 18 pounds per cubic foot; at 320 degrees Fahrenheit to produce a foam density of 10–12 pounds per cubic foot. The temperature then can be raised gradually and the foamed resin given a final cure. The properties of foamed Dow Corning *XR-543* resin suggest its use in applications where extreme temperature resistance is required, and high compressive strength is not essential.

All-Welded Junction Transistors. The General Electric Company has announced production of all-welded junction transistors with essentially infinite life expectancies. The units are evacuated, hermetically sealed, and of all-welded metal construction. They are the first to have all-welded construction which eliminates the aging effects of moisture and trapped solder flux fumes. The welded metal construction allows power ratings of almost 1 watt, with two units in a class *B* push-pull circuit. They have been demonstrated to operate under water at temperatures up to 100 degrees centigrade.

Current Transformer for Outdoor or Indoor Service. Availability of a "thru-type" current transformer (type *TWM*) for indoor or outdoor service has been announced by the Allis-Chalmers Pittsburgh, Pa., works. The transformer is molded in thermosetting resin which serves as insulation, support, and casing. This construction has an inherent toughness which promotes long life and is highly weather resistant. The unit can be mounted in vertical, horizontal, or inverted position and its base can be rotated 90 degrees for greater mounting position. The transformer has conventional accuracy for light burden metering.

Miniature Wide-Band Oscillograph. A wide-band, quantitative oscillograph which features quality, laboratory-performance, and versatility, with portability, has been announced by the Instrument Division, Allen B. Du Mont Laboratories, Inc. The instrument, type *301-A*, measures $9^1/_8$ inches high by $6^1/_2$ inches wide and $16^5/_8$ inches deep and weighs 20 pounds. Bandwidth extends from 10 cycles to 4 megacycles. Circuits for precision calibration of both time and amplitude are incorporated. Primary power requirement is 115 volts, 50 to 1,000 cycles, permitting operation from almost any field power source. Complete electrical and mechanical specifications are available from the Technical Sales Department, Instrument Division, Allen B. Du Mont Labora-

(*Continued on page 64A*)

ROOM FOR 5 MORE CONDUCTORS

WHEN IT'S

ROCKBESTOS PNR

CONTROL CABLE

Both conduits are 1 ¼″ D. But the one on the left carries 12-conductor PNR #9 AWG — 5 more conductors than the conventional 7-conductor #9 AWG cable below. That's because Rockbestos PNR is 46%* smaller in area. A better insulated control cable that saves you steel conduit, fittings and labor. Write for the full PNR story.

PNR 12-conductor #9 AWG in 1 ¼″ conduit.
Conventional 7-conductor #9 AWG in 1 ¼″ conduit.

*Average determined by comparison with competitive control cable.

PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

ROCKBESTOS
PRODUCTS CORPORATION
NEW HAVEN 4, CONNECTICUT

NEW YORK • CLEVELAND • DETROIT • CHICAGO
PITTSBURGH • ST. LOUIS • LOS ANGELES
NEW ORLEANS • OAKLAND, CALIFORNIA • SEATTLE

Quick facts about

PNR

46% smaller area* . . . 28% smaller diameters*. Use smaller conduit and fittings, or put more conductors in present conduit.

Dielectric breakdown . . . over 40 times operating voltage.

Lighter and smaller. Easier to handle, store, ship, pull through conduit.

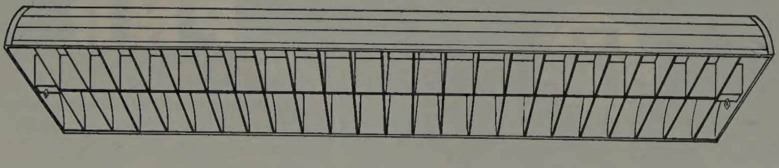
Flexible to —25°C (—13°F). No cracking!

Rated 600 volts . . . conductor operating temperature 75°C (167°F).

eyes:

Save pupils' eyes. Save school-lighting dollars. The new MILLER LEXINGTON provides well-shielded overall illumination of high efficiency and low brightness at LOW OVERALL COST. Rigid Quality construction, with long-life finishes. Engineered for quick, easy installation. Low maintenance. Long, dependable life. Write for details.

DESIGN: *Functional—clean, simple lines.*
EASY *2-way lamping—1 ladder position.*
STRENGTH: *Rigid 1-piece steel louver.*



THE **miller** COMPANY, *Meriden, Connecticut*
LEADERS IN LIGHTING SINCE 1844

(*Continued from page 60A*)

tories, Inc., 760 Bloomfield Avenue, Clifton, N. J.

Outdoor Oil Circuit Breaker. A 3-phase oil circuit breaker, type *G*, for 14.4- and 23-kv distribution service is available from the Westinghouse Electric Corporation. The type *G* breaker utilizes a single oil tank to contain all three circuit breaker poles. To inspect or service the breaker, all three poles are exposed simultaneously by lowering a single tank. One enlarged De-ion grid arc interrupter per pole replaces the previous two per pole, giving the breaker ample short-circuit capacity with smaller over-all dimensions. A single housing encloses the solenoid operating mechanism and associated control. The operating solenoid, control relays, terminal blocks, and rectifier, when required for a-c control, are mounted on the back of the housing. Continuous current ratings are available up to 1,200 amperes with 8-cycle arc interruption up to 250 megavolt-amperes. For further information write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Low-Voltage Control Switches and Relays. Flexibility and versatility are features of low-voltage control switches and relays introduced by the Square D Company. These are components of the new 24-volt switching system, *LV* control. Individual *LV* control switches mount on standard Despard-type straps. Both toggle and key-operated switches are available. Relays are rated 20 amperes, 120 volts, alternating current for $^1/_2$ horsepower or 20 amperes, 277 volts alternating currents for fluorescent loads. Relay design is 2-coil type. For details, write Square D Company, 6060 Rivard Street, Detroit 11, Mich.

TRADE LITERATURE

Electronic Tubes. Amperex Electronic Corporation has issued a condensed catalogue of its electronic tubes. The catalogue has been compiled for those in the engineering field who seek the proper tubes to suit their applications. It also is intended to serve as a quick reference guide and a dependable source of supply for initial equipment as well as replacement. The catalogue is available on request from Amperex Electronic Corporation, 230 Duffy Avenue, Hicksville, N. Y.

Miniature Indicator. Construction, installation, and design features of a remote miniature indicator are described in a 12-page bulletin by the Fischer and Porter Company. The bulletin uses photographs to show construction of the bellows spring assembly, which is the heart of the instrument, as well as details of other components. The bulletin describes incorporation of the

(*Continued on page 72A*)

FOR PRECISION MEASUREMENT

Standardize Surfaces with G-E Roughness Scales and Specimens

Filter Manufacturer Cuts Spoilage Costs Up To 90% With G-E Roughness Scales

Air Maze Company, Cleveland, Ohio, manufacturers of filters for all purposes say that their G-E surface roughness scales and specimens have reduced manufacturing expenses by cutting spoilage costs 90%. "They have provided us with real savings in both time and money," stated H. W. Matlock, chief draftsman for Air Maze.

HANDY, LIGHT WEIGHT

Daily use is made of the roughness specimens in preparing the specifications and blueprints for component filter parts. Then, with the handy lightweight scales, Air Maze makes certain that the finishes on parts received from their vendors are correct. When there is a question as to the suitability of a standard part, the roughness scales end the argument, this company reports.

At Air Maze Company, component parts are checked for proper roughness with General Electric surface roughness scales.

ASSURE UNIFORM SURFACES

G-E surface roughness scales and specimens are particularly valuable when parts, manufactured by several subcontractors or by different departments in one manufacturing plant, must have uniform surfaces roughness. The scales and specimens provide a common basis for the engineer, draftsman, machinist, and inspector in determining, supplying, and approving the correct surface finish.

FLEXONICS CORP. INSPECTOR USES SPECIMENS TO ASSURE STANDARDIZED SURFACES

Roughness Specimens Aid in Manufacture of Aircraft Parts

Referring to their General Electric surface roughness specimens, Fred O. Allen, Chief Inspector of the Elgin Division of the Flexonics Corporation said, "We just couldn't do without them. They provide us with a standard to go by, prevent a lot of controversy or differences of opinion, and as a result, save us considerable time."

The Elgin Division of the Flexonics Corporation, Elgin, Illinois, manufactures component parts for jet engines and other aircraft assemblies. These parts, which require precise surface roughnesses, are given production as well as final inspection with General Electric surface roughness specimens to assure uniformity and adherence to the specifications set up by the jet engine or aircraft manufacturer.

FURTHER INFORMATION

A complete set of G-E standard roughness specimens consists of ten metal blocks. The complete set is priced at only $85.02*. General Electric's surface roughness scales are composed of two small metal rules. The price of both scales is but $20.12*. Further information about the many uses for these highly versatile tools may be obtained from your nearest G-E Apparatus Sales Office, or simply check the coupon below for Bulletin GEC-774.

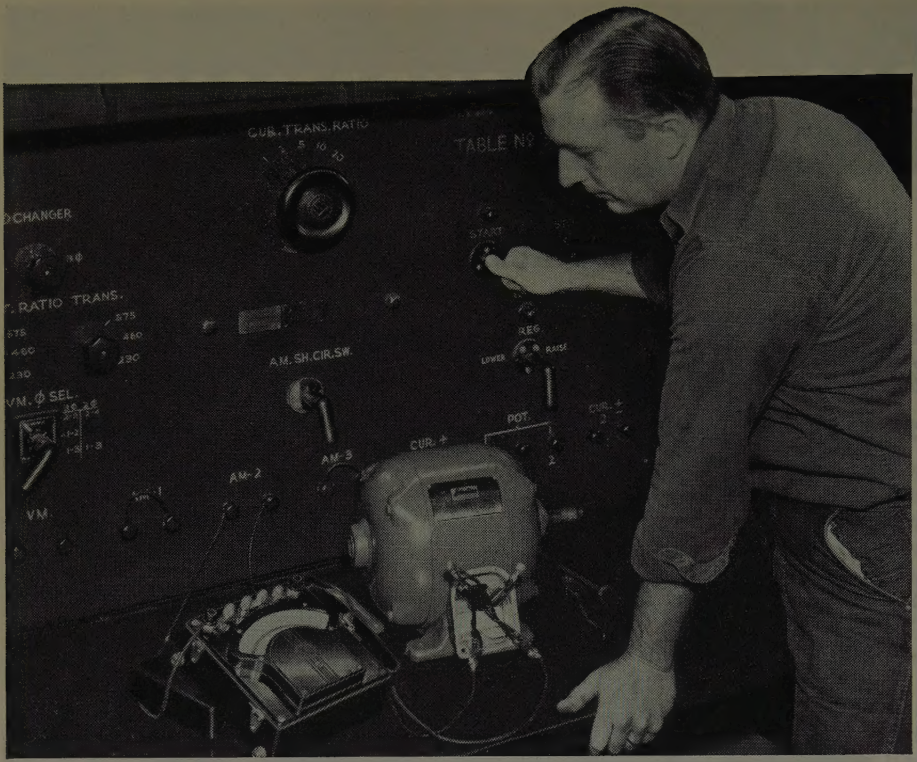
SECTION C605-54, GENERAL ELECTRIC COMPANY, SCHENECTADY 5, N. Y.

Please send me the following bulletins:

☐ **Roughness Scales and Specimens (GEC-774)**
☐ **Leak Detector (GEC-233)**

NAME..
COMPANY..
STREET..
CITY.................. ZONE.......... STATE..........

GENERAL ELECTRIC



Westinghouse portable ammeters stand overloads 35 times full scale

Westinghouse portable a-c ammeters with full-scale ranges of 5 amperes will withstand motor-starting surges of 175 amperes without damage. They will take 100 amperes for 2 seconds and 25 amperes for a full minute. Instruments with greater full-scale ranges have proportionally greater overload capacity.

You get this kind of resistance to overloads only in Westinghouse instruments because of the exclusive Hipernik® alloy steel repulsion vanes. When the current in the circuit being measured increases to twice the full scale rating of the instrument, these repulsion vanes become saturated and the force on the moving system is thus limited to a safe value. Because saturation occurs so quickly, the instrument withstands overloads that would seriously damage other instruments.

Trainees, students, and sometimes even experienced electrical testers, may connect a portable ammeter incorrectly by mistake. If the ammeter is a Westinghouse, the chance that it will be damaged by the overload is greatly minimized. On overloads caused by motor starting surges, there is no chance of damage at all. Try them and see. J-40430

EVERYTHING YOU NEED IN METERS AND INSTRUMENTS

YOU CAN BE **SURE**...IF IT'S
Westinghouse

FREE CATALOG
For additional information about the COMPLETE LINE of Westinghouse portable instruments, write for Catalog CS 43-100 or send this coupon to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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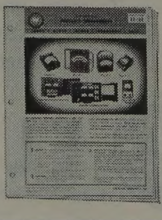

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various types of warning devices in the instrument. Also covered is the method for setting up a control transfer station both to monitor a process variable and to reset the controller regulating a diaphragm motor valve. Copies are available from Fischer and Porter Company, 11A Jacksonville Road, Hatboro, Pa.

Insulating Joints. A bulletin describing insulating joints for piping lines to electrolytic plating, cleaning, and anodizing tanks used by metal working industries has been released by Barco Manufacturing Company. This is a development pioneered by Barco for providing an electrical insulating barrier in a pipe without interfering with its capacity or efficiency for conveying steam, water, chemicals, or gases. Besides promoting safety and preventing wasteful leakage of current, the joints are useful in preventing pitting or corrosion due to electrolysis. Complete information may be obtained from Barco Manufacturing Company, Department J-57, 500 Hough Street, Barrington, Ill. Ask for bulletin *223*.

Handi-Tool Guide. A wide assortment of tools for the repair and maintenance of radio-television-electronic equipment is cataloged in a 36-page booklet called Handi-Guide. It contains detailed specifications, illustrations, technical data, and prices on tools made by 17 leading manufacturers. Included are television alignment tools, chassis punches, pliers, screw and nut drivers, soldering irons and guns, tool kits, wire strippers, and so on. Free copies of this guide may be obtained by writing to United Catalog Publishers Inc., 110 Lafayette Street, New York 13, N. Y.

Dual-Beam Cathode-Ray Voltmeter. A bulletin on the new Du Mont Type *322-A* Cathode-Ray Oscillograph is now available from the Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J. It contains complete technical specifications, description, and photo-recordings made with the new instrument. The Type *322-A* is an improved, redesigned counterpart of the Type *322* with the added feature of built-in independent voltage calibration for both beams, and also incorporates the new tight-tolerance Type *5AFP* cathode-ray tube.

Tables for Voltage Drop. A booklet of tables for the determination of voltage drop in copper and aluminum conductors compiled by engineers of the United States Rubber Company has been made available for general use. In these tables, an attempt has been made to simplify and reduce to a minimum the computations associated with most voltage drop tables now in use. The tables, which read directly in volts, have been pretested in the field and found to be practical and workable. Copies of the booklet may be obtained, in limited quantities, from the United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.